8/6

David Prain

CAB INTERNATIONAL
MYCOLOGICAL INSTITUTE
LIBRARY

IMI / Books / BAR ✓

COMMONWEALTH MYCOLOGICAL INSTITUTE
28 OCT 1959

A

DESCRIPTIVE LIST

OF THE

UREDINEÆ

OCCURRING IN THE NEIGHBOURHOOD OF

SIMLA (WESTERN HIMALAYA)

BY

A. BARCLAY, M. B.,

BENGAL MEDICAL SERVICE.

[*Reprinted from the Journal of the Asiatic Society of Bengal, Vol. LVI, Part II, No.* 3, 1887.]

1943

CALCUTTA:

PRINTED BY G. H. ROUSE, AT THE BAPTIST MISSION PRESS.

1888.

Digitized by the Internet Archive
in 2024

https://archive.org/details/unset0000unse_p2n1

A Descriptive List of the Uredineæ *occurring in the Neighbourhood of Simla (Western Himalayas).—By* A. Barclay, M. B., *Bengal Medical Service.*

[Received 7th October ;—Read November 2nd, 1887.]

(With Plates XII.—XV.).

The neighbourhood of Simla is particularly rich in species of Uredines ; and, as I have paid much attention to them during the last four years, it has been suggested to me that a descriptive list of them might usefully be recorded for the use of future workers in this very interesting field of cryptogamic botany. I have acted on the suggestion after much hesitation, for, with the very limited leisure at my disposal in the course of an active official life, I cannot hope to make the list a complete one, nor, indeed, can the descriptions of many of those I notice be as complete as might be desired. Nevertheless, so far as they go, my statements may, I hope, be accepted as correct in every respect, for every one of them has been made after careful and repeated observation. I may, therefore, be permitted to hope that the list may serve some useful purpose, more especially as no such attempt has ever before been made in India, so far as I am aware.

With regard to the order in which such a list should be given, I have determined, after some hesitation, to bind myself by no very strict rule, but, in general, to enumerate, first, all those species which bear aecidial fructification and, then, to go on to those which are at present known to me only in the teleutosporic stages. With reference to the æcidium-bearing species, I may note that I have described them generally as they occur in seasonal sequence, beginning with those which appear earliest in spring, and ending with those which disappear last towards autumn. The only exception I have made in following out this plan is to withdraw from the general list all those forms which occur on the Coniferæ, as I thought it better to enumerate the characters of these few well defined species together, rather than to disperse them among the others, which occur on hosts having no special relationship with one another.

In the present contribution, I will confine myself to the æcidial forms with which I am acquainted on hosts other than the Coniferæ ; but, before proceeding to a description of them, I may draw the attention of the reader to one or two points of special interest concerning them.

In the first place, it will be observed that I have related several of them with a mark of interrogation to species already described as occurring in Europe. Until the complete life-histories of these are known, it is impossible to state definitely whether they are correctly so related or not. They are probably all varieties of, or identical with, the European forms with which I have associated them. In only one case (that of *Æcidium Urticæ*, Schum.) has the life-history of the Indian variety been fully traced.

Five of the species described are I believe quite new, in only one of which *(Æcidium Strobilanthis)* have I been able to trace the whole life-history. That on the wild strawberry (*Fragaria vesca*) appears to be a complete autoecious Uredine, but I have unfortunately not been able to prove this by actual experiment. And, in this connection, I would again draw attention to the inconvenience caused by the system of nomenclature now adopted of naming species of Uredines after their teleutosporic forms, an inconvenience which it appears to me will increase as our knowledge of this family is extended, for it sometimes happens that a host bearing an æcidium bears also a teleutospore, which, however, has no relationship whatever with the æcidium. For example, according to this principle, I have been obliged to name the Æcidium which occurs on *Valeriana Wallichii Uromyces Valerianæ*, although I have abundant evidence that the teleutospores have no genetic relationship whatever with the Æcidium. In all probability, future investigation will show that the Uromyces borne on this host is related to some other Æcidium on an entirely different host, whilst the teleutospores borne on some other host are related to the Æcidium on the Valeriana in question. In the cases of *Strolilanthes Dalhousianus* and *Urtica parviflora*, which bear Æcidia whose complete life-histories are known, teleutospores (puccinia) are also borne, which, however, have no relationship with the Æcidia.* The Æcidium on *Jasminum revolutum* presents no unusual features, but those on *Euphorbia cognata* and *Andrachne cordifolia* display aberrant features of great interest. Indeed, these two Æcidia differ so markedly from all others that I have regarded them, provisionally, and until I shall have had further opportunities of working out their complete life-histories, as belonging to a new genus, which I propose calling Monosporidium.

With these introductory remarks I shall pass on to a description of the several species.

* *See* " Scientific Memoirs by Medical Officers of the Army of India, " Part II, Calcutta, 1887.

I.—ÆCIDIAL FORMS.

1.—Æcidium Saniculæ, sp. nov.

Sanicula (Europæa, L. ?)

The earliest Æcidium which I have observed in Simla is that which occurs on *Sanicula Europæa.* Towards the latter end of March, some of the earliest leaves of this plant which are being unfolded in spring may be found attacked by this parasite. It is by no means an uncommon fungus. The invaded areas of the leaf are usually small, and generally convex below, where the aecidial cups are usually borne, though a few may open also on the upper surface of the leaf. The æcidia discharge their spores through a *porous* like opening at their summits, *i. e.*, the peridium does not open widely as in most cases with the fragments of the torn tissue forming a *stellate* opening. The petioles are also frequently attacked and at such places they are thickened and often bent. A single leaf blade may present from one to three patches of invasion, these patches being slightly paled in colour as seen from the upper surface.

Æcidiospores.—The moistened æcidiospores measure on an average 25·4 × 19·4 μ, the measurements exhibiting extremes of 26 μ in length and 20 μ in breadth. The epispore is finely punctated and contains from two to three germ pores. The endospore is very fine and not readily distinguishable from the epispore (Fig. 1, Pl. XII.). The spores, when placed in water under suitable circumstances, readily germinate, throwing out long curved tubes measuring 6 to 7 μ in diameter. Only one germinal tube is produced by each spore. The peridial cells measure about 30 × 22 μ (Fig. 2, Pl. XII.).

Remarks.—This æcidium is, I believe, a new species ; but may be compared with that which I have described below on *Pimpinella diversifolia.*

2.—Uromyces Valerianæ, Schum ?

Valeriana Wallichii, D. C.

Next to the foregoing Æcidium one on this plant is among the earliest of these parasites to be found in spring. Towards the end of March, some plants may be found in initial stages of attack ; but it is towards the latter part of April that it is seen in its fullest development. This Æcidium is one of the most common and abundant in Simla, and individual plants are often so extensively affected in blade and petiole as to be completely destroyed. The affection is usually confined to the blades and petioles of the radical leaves, but may also be found on the upper leaves of the flowering stalks and even, though rarely, on the bracts of the flower heads. When a leaf is extensively affected, it is considerably distorted, and the parts actually

invaded by the mycelium are considerably thickened. At an early stage of the affection, patches of pale yellow discoloration may be observed on the leaf blades, which are usually convex above. On this upper convex surface, a few spermogonia may be seen, whilst the æcidial fructification usually emerges from the lower or concave side. The æcidia consist of short tubular peridia filled with reddish yellow spores bursting at their summits in a stellate way.

The spermoginia are remarkably few and their mouths are surmounted by a tuft of paraphyses.

The æcidial affection above described is met with abundantly throughout the time the plants are in flower, but, as soon as the seeds are being matured, towards the middle or end of May, this affection disappears entirely. After an interval of some weeks from the time the æcidial parasite has entirely disappeared, these plants are seen to be attacked by a teleutospore-bearing mycelium also mainly on the radical leaves, though occasionally also on others. This affection always appears on leaves which bear no trace of formerly having borne the æcidial parasite. The spores are extruded from dark brown pustules of minute size, which usually occur in great numbers on each affected leaf. Each pustule is surrounded by a zone of yellow discoloration. At first, these spores are extruded only from the upper surface of the leaf, but later also from the lower surface, exactly opposite the site of the upper spore bed and therefore from the same mycelium. The lower pustule is usually smaller than the upper. At first, when a spore pustule exists only in the upper surface of the leaf, the affected area bulges upwards (convex upwards) with a corresponding concavity below; but this disappears when the lower surface is also involved in spore extrusion.

Æcidiospores.—These are abstricted serially from basidia arranged on a flat hymenium. They are pale orange-yellow round or oval bodies measuring, when dry, $17 \times 15\ \mu$ and, after lying some time in water, $22 \times 20\ \mu$ (Fig. 12, Pl. XII.). The epispore is smooth and unmarked. They do not germinate readily in water (Fig. 10, Pl. XIII.). The peridium consists of a layer of single cells.

Teleutospores.—These are brown single-celled bodies—Uromyces—borne singly on stalks (Fig. 13, Pl. XII.). They are somewhat pear-shaped, measuring when moist $25 \times 22\ \mu$, and the stalks bearing them are about twice the length of the long diameter of the spore. The spores are readily detached from their beds without any portion of the stalk adhering to them. The epispore is firm and resistant and a little thickened towards the base, where it joins the stalk. It is sparsely beset externally with tubercles. A few fine paraphyses usually occur

among the spores. Most spores exhibit a nuclear space or body in the centre. Although I placed them in several nutritive solutions and in water, I never observed them germinating.

Remarks.—I have made very numerous experiments with the view of tracing the life-history of this very common Æcidium, but without success. I am quite convinced that the teleutospore-bearing fungus has no connection whatever with that bearing the æcidium, not only because many carefully conducted experiments failed to establish any such connection, but also because a considerable interval elapses, as I have already noted, between the complete disappearance of the Æcidium and the appearance of the teleutospores. I have also attempted to reproduce the Æcidium by inoculating leaves with almost every teleutospore with which I am acquainted, and most of which I hope to describe later in this series.

This fungus may be identical with *Uromyces Valerianæ*, Schum, in which the æcidiospores are stated to measure 17 × 24 μ and the Uromyces spores, 20 to 26 by 15 to 19. The latter fungus, however, also possesses uredospores, which are entirely absent in the Himalayan species.

3.—Puccinia Violæ, Schum ?

Viola serpens, Wall.

An Æcidium of a very destructive kind is extremely common on *Viola serpens* in spring (April) and occurs simultaneously with that described on Valeriana. As a rule, large areas of the leaves become affected and very frequently the petiole also is extensively involved. Sometimes there is scarcely a portion of the whole leaf, blade and stalk, which is not involved, and, in such cases, the whole leaf speedily succumbs to the parasite. In such extreme cases, the blade of the leaf is crumpled up almost beyond recognition, while the affected stalk is bent in various directions and considerably hypertrophied. Limited patches on the leaf blade are generally round and very deeply bulged downwards, *i. e.*, with a concavity upwards. The æcidia are borne most usually on the under surface of the leaf, but a few burst forth also from above. But little discoloration is caused by the mycelium on the upper surface of the leaf, which is only slightly paled.

Later in the season, about the beginning of June, when the æcidial fungus has disappeared, the new leaves of the violet are often attacked by another puccinia-bearing parasite. Many leaves may now be found, in the same localities where formerly the æcidial parasite was common, studded with numerous dark brown or black pustules of the size of a small pin's head, mostly on the under surface. These pustules are irregularly scattered over the leaf blade, bursting through the epi-

dermis (after having raised it considerably) by a clean rent. Opposite the pustules, on the upper surface of the leaf, small greenish yellow spots may be seen. Although the greater number of pustules emerge from the lower surface, yet many also burst forth from the upper surface, especially when the leaf is very largely attacked (Figs. 4 & 5, Pl. XII.).

It has been stated above that these puccinia-pustules are usually borne on newly unfolded leaves, but, in one or two instances, I found the dried up remains of *æcidial* patches on the petioles of leaves which bore these teleutospores. This observation naturally led me to think that the two forms were genetically related, and I accordingly made numerous attempts to establish the relationship upon experimental grounds, but always without success. I am therefore inclined now to regard the two parasites as entirely distinct, and I am supported in this view here, as in the case of Valeriana above, by the fact that, as a rule, a distinct interval of about a month or more elapses between the complete disappearance of the æcidium and the appearance of the teleutospores; and it is quite exceptional to find any trace of old æcidia on plants bearing the puccinia-producing mycelium. I may here note that I have made numerous attempts during the last two years to connect the Æcidium on the violet with several teleutospores occurring on various plants in Simla, but, as in the case of the even more common Valeriana Æcidium, always without success.

Æcidiospores.—When well moistened in water, the spores measure 21 × 18 μ, but, when dry or immediately after immersion in water, they measure on an average 19 × 14-8 μ. They readily germinate in water, throwing out a single more or less sinuate tube measuring about 6 μ in diameter (Fig. 6, Pl. XII.). This germ-tube has a tendency to throw out short lateral branches. The orange-red contents of the spore wander into the furthest end of the tube. The spores appear to have 3 to 4 germinal pores, but only one germ-tube is formed by each.

Teleutospores.—These are dark brown puccinia easily detached from their beds without any portion of the stalk remaining adherent (Fig. 7, Pl. XII.). When dry, these spores measure as follows:—whole length, 30 μ; length of upper cell, 14 μ; length of lower cell, 16 μ; breadth at septum, 18 μ. The spores are somewhat thickened at their free ends, sometimes to the extent of 4 μ. Among these puccinia-spores, a few single-celled spores were often found which may have been either uredospores or a second form of teleutospore. They are brown bodies with thick resistant walls covered externally with prominent tubercles. They measure, when dry, 20 × 18 μ on an average: I never observed their germination. Some freshly collected spores were

placed in water in a growing cell on the 20th March, and they germinated freely, although some spores preserved in botanical drying paper since the previous autumn had lost vitality (Figs. 7 & 8, Pl. XII.). The promycelium from the upper cell emerges from the apex, whilst that from the lower cell emerges from a point close to the septum. The promycelium produces four sporidia from four cells into which the end of the promycelium is divided, the most distant one being produced upon a sterigma arising from the very apex of the germ-tube (Figs. 7, 8, 9, Pl. XII.). The sporidia are oval, measuring from 6 × 4 μ to 7 × 5 μ (Fig. 10, Pl. XII).

Remarks.—It is possible that this fungus is identical with, or, more probably, a variety of, *Puccinia Violæ*, Schum., although the measurements of the latter given by Winter* do not agree with mine very nearly. Winter's measurements are as follows:—æcidiospores 16 to 24 μ by 10 to 18 μ (average 20 × 14 μ) against my measurement of 21 × 18; uredospores 19 to 26 μ in diameter against my measurement of 20 × 18 μ; teleutospores 20 to 35 μ by 15 to 20 μ (average 27·5 × 17·5) against my measurements of 30 × 18 μ. The characters of the teleutospores as given by Winter agree with those of mine.

4.—Puccinia Pimpinellæ, Strauss.

Pimpinella diversifolia, D. C.

The next æcidium which attracts attention is not so common as those above described, and occurs on *Pimpinella diversifolia.* This parasite may be found in certain localities towards the end of April or the beginning of May, and is very soon after that missed again. Indeed, towards the end of May, it has already become very scarce. The fungus usually attacks the first leaves that are unfolded of this plant, these being simple leaves of the shape of the common violet leaf. The compound leaves later unfolded were very rarely found attacked. The invaded areas of leaves are discoloured, becoming pale yellowish green, and the æcidia are borne almost wholly on the under surface, though a few occasionally break through the upper surface. The æcidial fruit consists of tubular peridia measuring about 2 to 2·25 m.m. in length which burst at their summits in a stellate manner. In addition to the leaf blade, the petiole is not unfrequently attacked, and here the peridial tubes are somewhat longer than they are on the leaf blade. Several distinct patches of æcidia sometimes occur on a single petiole, but in such cases the blade is also largely affected. At these places on the petiole the tissues are somewhat hypertrophied. The leaf blade also where invaded is thickened, the depth of the laminal tissues at

* Die Pilze Deutschlands, &c. Von Dr. George Winter.

such places being about 0·441 m.m., whilst the normal thickness is about 0·239 m.m.

A little later, towards the end of May, when the æcidial parasite is becoming rare, some of the compound leaves (never the simple ones) may be found attacked by a separate mycelium bearing uredospores. This uredospore-bearing mycelium is never found on the same leaf bearing æcidiospores, and it is therefore quite probable that the two mycelia are in no wise genetically related to one another. The uredo-pustules are minute, circular, and saffron-coloured, mostly on the upper surface of the leaf, though by no means infrequently also on the lower. Sometimes the upper surface of a leaf may be seen to be densely covered with these uredo-pustules.

Again in autumn, about the end of September and October, the same plant may be seen largely affected by a puccinia-bearing fungus, a distinct interval having elapsed since the disappearance of all trace of the uredo-bearing fungus. These puccinia-pustules are minute and round, like the uredo-pustules, but black, and occur both on the upper and lower surfaces of the leaves, sometimes in great profusion. The stem is also often affected; the pustules here are linear, their long axes corresponding with the long axis of the stem.

The *æcidiospores* are reddish yellow with very thin walls, the epispore and endospore not being distinguishable from one another: they are round, oval, or somewhat fusiform (Fig. 14, Pl. XII.). The round spores measure 20 to 21 μ in diam., the oval about 32 $\times$ 20 μ, and the fusiform about 38 $\times$ 14 μ, shortly after being wetted with water.

The *spermogonia* are likewise situated on the under surface of the leaf: they measure about 0·163 m.m. in depth and 0.189 m.m. in breadth. Their mouths are beset with paraphyses projecting about 0.063 m.m. The spermatia are round or oval and measure 4 $\times$ 3 μ.

The *peridium* consists of elongated cells, very unlike those of the æcidium on Sanicula described above, measuring about 60 $\times$ 20 μ, and easily detached from one another by teasing (Fig. 15, Pl. XII.).

Uredospores.—These are reddish yellow round or oval bodies with coarse tubercles on the surface of the epispore. On an average, the moistened spores measure 22 $\times$ 18·3 μ. They germinate readily in water. (Fig. 3, Pl. XII.).

Teleutospores.—These are brown two-celled bodies (puccinia) readily detached from their beds with a very small portion of the stalk remaining adherent to them. In each cell, a clear nuclear body or space may be seen. The epispore is marked externally by fine ridges. They are not thickened at their free ends. As with the uredospores, I never succeeded in getting them to germinate in water. Their measurements

are as follows :—whole length of spore 30 μ; length of lower cell 13 μ and of upper cell 17 μ; breadth at septum 23 μ; extreme breadth of upper cell 24 μ and of lower cell 22 μ.

Remarks.—At first it seemed extremely probable that all the three forms above described were phases of one fungus, and I attempted frequently to establish a relationship between them by experiment, but always without success. This alone, however, does not justify me in definitely denying a relationship between them, since it is quite possible that some condition of my experiments militated against the manifestation of a relationship. However, the experiments were carefully conducted and often repeated. I also attempted to reproduce the æcidium by laying the teleutospores found on several grasses in the neighbourhood on the young leaves; but in these attempts also I failed.

This parasite is probably identical with *Puccinia Pimpinellæ*, Strauss. in which the æcidiospores are said to measure 18 to 35 μ long and 16 to 21 μ broad (average 26·5 × 18·5 μ), the uredospores, 23—32 μ long and 19 to 24 μ broad (average 27·5 × 21·5), and the teleutospores, 26 to 35 μ long and 17 to 26 μ broad (average, 30·5 × 21·5). The only feature in which this fungus differs from that which I have described is in the characters and size of the uredospores. In Strauss's plant the uredospores are said to be pale brown, while in mine they are reddish yellow and smaller.

5.—Puccinia coronata, Corda ?

Rhamnus dahuricus, Pall.

The Æcidium which occurs on this plant is not very common, although occasionally an attacked tree or bush is very extensively affected. The fully ripe æcidium may be found as early as the latter part of May, but it is more usually met with about the middle of July. The fungus attacks leaves, young stem (Figs. 1, 2, 3, Pl. XIII.), and drupes, the last sometimes very extensively indeed. When the leaf is attacked, the invaded areas are usually small, and generally only one patch occurs on each leaf. These patches are dark reddish brown above, surrounded by a halo of pale yellow (Fig. 2, Pl. XIII.), and the orange-yellow æcidia are borne on the lower or concave surface of the leaf, opposite the dark central part seen above (Fig. 1, Pl. XIII). The red colour of the patch is due especially to discoloration in the palisade cells, and the abnormal thickness to hypertrophy of the spongy tissue, the palisade cells retaining their normal dimensions and characters. The tissues in the areas invaded are very extensively permeated by hyphæ, and many cells are destroyed. While the thickness of the leaf blade is normally 0·126 m.m., it is about 0·440 m.m. in patches bearing ripe

æcidia. A patch of ordinary size measured 1 c.m. in total diameter, the central reddish brown part measuring 6 m.m. in diameter. The patches are sometimes considerably larger, however, and more irregular in shape. The æcidia are tubular structures, very deeply sunk into the laminal tissue, measuring about 1·75 m.m. in length, and therefore resembling in some degree the Æcidium on *Pyrus variolosa* described below. With very few exceptions, the æcidia burst from the lower surface of the leaf. These patches on the leaves are often placed near the margin of the leaf, and are usually between and not over the principal veins; but when a vein is involved it is considerably thickened. When the stem is attacked, which occurs but rarely, it is considerably swollen. The drupes when attacked are often densely covered with æcidial tubes, set at right angles, all over them.

The *spermogonia* are formed on both the upper and lower surfaces of the patches, and may often be found ripe when the æcidia on the same patches are also fully developed. They are inserted between the cells of the single layer of palisade cells when situated on the upper surface. They have a tuft of paraphyses protruding through their mouths, and measure about 0·107 m.m. in depth and breadth.

The *æcidiospores* are round orange-yellow bodies of very uniform size measuring 23 μ in diameter when recently wetted with water (Fig. 5, Pl. XIII.). The *peridial* cells are roughly hexagonal, adhere very firmly to one another, and measure about 26 $\times$ 16 μ. The centre of each cell contains orange-yellow matter like the contents of the æcidiospores (Fig. 4, Pl. XIII.).

Remarks.—There can be little doubt that this Æcidium is caused by a Puccinia, with all the characters of *Puccinia coronata*, which occurs on *Brachypodium sylvaticum* in Simla, but unfortunately I have not had sufficient opportunities of verifying this. So far as my insufficient experiments go, I have always obtained negative results. I am also not quite sure whether this Æcidium does not also occur on *Sageretia oppositifolia*.

6.—Puccinia Fragariæ, nov. sp.

Fragaria vesca, Linn.

During May, and just before it flowers, the Wild Strawberry, *Fragaria vesca*, may in some years be seen attacked by an æcidial fungus. This parasite is, however, a rare one, and I found it on two occasions only in 1885 at localities distant a few miles from one another, and on each occasion only a single affected plant was found. Æcidial fructification was found both on the petiole and on the leaf blade. It is somewhat curious that the same leaf bore *simultaneously* uredo and teleutospore pustules, but all the three forms of spore-pustules were quite distinct

from one another, with green normal tissue between them—at least, I could not trace any mycelial connection between them. The æcidial fructification consists of groups of æcidia on the margins of the leaves. The portions of the leaf blade bearing these quickly wither and dry up after the æcidia ripen. The æcidia break through both the upper and lower surfaces of the leaf, but more frequently from the lower. Spermogonia of the usual form are frequently present, especially on the petiole when this is affected, and they are placed usually close by the side of the æcidia.

The *æcidiospores* are pale yellow and very irregular in size and shape, varying from round to oval, often faceted and irregularly angular. Their average measurements when moistened are 22 × 15·8 μ The epispore is finely punctated (Fig. 6, Pl. XIII.). Placed in a decoction of cow-dung (Brefeld) several in 24 hours threw out short germinal tubes of an average diameter of 5·3 μ, but the greater number of spores would not germinate.

The *uredospores* are oval or pear-shaped and pale yellow in colour (Fig. 7, Pl. XIII.). They are produced in little circular yellow pustules, which are situated on both surfaces of the leaf. The external surface of the epispore is beset with prominent tubercles. The moistened spores measured on an average 21 × 17 μ. Placed in a decoction of cow-dung, only two were found to have germinated on the 5th day, whilst those placed in water did not germinate at all (Fig. 8, Pl. XIII.). The *teleutospores* are contained in little black pustules situated close to the æcidial fructifications. They were produced on both the upper and lower surfaces of the leaf blade, but more frequently on the lower surface, as in the case of the æcidia. The spores are dark brown, two-celled bodies, puccinia, easily detached from their beds, breaking off with only a small fragment of stalk adhering (Fig. 9, Pl. XIII.). The average measurements of these spores when moistened were as follows:—whole length 31·7 μ; length of upper cell 15·8 μ, and breadth of same 22·4 μ; length of lower cell 15·8, and width of same 21 μ. The stalks bearing these spores are from 2 to $2\frac{1}{2}$ times the whole length of the spore. Amongst these teleutospores a few uredospores occurred of the characters above given. The teleutospores were sown in a decoction of cow-dung, as well as in water, but they did not germinate. On one occasion, in autumn (November), I found a single leaf of this plant plentifully covered with teleutospore-pustules. I did not succeed in getting them to germinate.

From want of sufficient material, I could not experimentally determine a genetic relationship between these different spores, but the close proximity of the teleutosporic sori to the æcidial fructification and

the occurrence of uredospores in the teleutospore-pustules lend some support to the view that we have here to do with a complete autoecious Uredine. However, in the absence of experimental evidence, this remains a mere presumption.

Remarks.—I believe that this is an entirely new species, and I have therefore named it *Puccinia Fragariæ*, in accordance with recognised precedent in nomenclature, although I should have preferred naming it *Æcidium Fragariæ.*

7.—Æcidium leucospermum, D. C.?

Anemone rivularis, Ham.

This fungus is remarkably localised. During the last three years, although I have looked for it everywhere about Simla, and the host may be found everywhere, I have found it in only two localities, one in Simla (Annandale), the other in a forest (Cheog) about 14 miles distant. In these localities I have found it in June, July, and the beginning of August, before the plant flowers. The most striking peculiarity of this æcidium is that it is white. The whole leaf is often involved, though generally only well-defined portions are, and frequently the margin of the leaf (Fig. 11, Pl. XIII.). The æcidia break out almost entirely from the under surface, though a few may occasionally be seen on the upper surface. When a young immature leaf is attacked, as is often the case, there is a striking arrest of growth, the leaf never attaining the usual size shown by sister leaves of the same plant which are not affected—indeed, a fully affected young leaf is often only one quarter the normal size. The petioles were never seen to be attacked. Sometimes every leaf of a plant was found attacked. The attacked areas after the ripening of the æcidia quickly turn brown and wither.

The *æcidiospores*, when just wetted, are round or oval and measure on an average 17·7 × 15·6 μ. The epispore is beset with very minute tubercles (Fig. 12, Pl. XIII). I never succeeded in getting them to germinate in a growing cell. The peridial cells measure about 18 × 16 μ.

The *spermogonia*, formed only on the upper surface of the leaf, measure about 80 μ in depth and 120 μ in breadth. They are very superficially situated, having their bases sunk only through the epidermis and resting on the palisade cells. A tuft of paraphyses projects through their mouths about 40 to 50 μ in length.

Remarks.—*Puccinia Anemones*, Pers., occurs on *A. nemorosa* and *A. ranunculoides*, forming powdery masses of teleutospores (without uredospores) on the under surfaces of the leaves. Each of these hosts also bears an Æcidium, that on *A. ranunculoides* (*Æc. punctatum*, Pers.) having violet-brown æcidiospores and that on *A. nemorosa*

(*Æc. leucospermum*, D. C.) having white spores. Although I have carefully searched for teleutospores on *A. rivularis* in Simla, I have never found them, and I am therefore constrained to call this Æcidium *Æc. leucospermum* in the meantime. Schröter, I understand, thinks the teleutospores on *A. nemorosa* are related to the Æcidium borne on the same host, whilst Fuckel relates the Æcidium on *A. ranunculoides* with the teleutospores borne on it. The Himalayan Æcidium would appear to throw some doubt on the connection between their teleutospores (*Puccinia fusca*, Relhan) and the two æcidia, or, at any rate, if that be indisputable, the Himalayan Æcidium must be entirely different, being most probably a heteroecious Uredine.

8.—Æcidium Thalictri flavi, D. C.?

Thalictrum Javanicum, Blume.

The Æcidium on this plant, as in the case of that just described on Anemone, is remarkably localised, although the host is widely diffused. It is therefore a rare parasite, although, in the localities in which it is found, it occurs abundantly enough. It is met with during the rains, in July, while the plant is flowering. Only the leaf blades are as a rule affected, but occasionally the petiole is also attacked, when it is considerably hypertrophied and distorted. Fig. 1, Pl. XIV. represents the petiole attacked in two places: in both cases it will be seen that the petiole has become considerably elongated and in one case also bent completely round through 360°. When the parasite attacks the leaf blades, little reddish yellow spots are formed as seen from above, measuring ordinarily from a minute point to 4 or 5 m.m. in diameter. Sometimes, however, the patches are much larger—in one case 1 c. m. in diameter—and then the leaf is considerably distorted, especially when a main vein is involved. These larger patches are reddish brown above. The attacked areas are generally convex above at first, but often, as the area becomes larger, the converse obtains. The patches are frequently placed over a prominent vein, which is then, within the affected area, considerably swollen. The number of patches on a single leaflet varies from one to twelve or perhaps more. These attacked areas on the leaf blade are considerably thickened: the normal thickness of these delicate leaves is 0·095, m.m., whilst near a young still immature æcidium it was found to be 0·410 m.m.

Spermogonia are formed abundantly both on the upper and lower surfaces, and to the naked eye appear as minute pellucid reddish yellow spots. They are of the usual structure, measuring about 63 to 80 μ in depth and 75 to 94 μ in width. These structures are well sunk into the leaf tissue. Their mouths are surmounted by a tuft of paraphyses

about 60 to 65 μ in length. The tissues of the leaf are not so greatly hypertrophied in the spermogonial stage as they afterwards become, the depth of the laminal tissues near a ripe spermogonium being 0·189 m.m. in one case.

The *peridium* (Fig. 13, Pl. XIII) consists of a single layer of angular flattened cells measuring from 31·5 or 37·8 μ in length by 16 to 31 μ in breadth, or on an average 33·6 $\times$ 23·21 μ, shortly after immersion in water. It opens stellately. The *æcidiospores* are oval or round (Fig. 14, Pl. XIII.) reddish yellow bodies with a smooth epispore. The contents are either homogeneous or granular, more usually the latter. When just wetted, they measure about 25 μ in diameter, and the epispore is about 1·5 μ to 2 μ in thickness. They are given off serially as usual from basidia, but there are intermediate cells between succeeding spores (Fig. 15, Pl. XIII.).

Remarks.—It may not be out of place here to refer to a very fine Æcidium on *Thalictrum minus*, Linn., which I found on the 7th May 1884 at Urni, a village on the Hindustan-Thibet road about 126 miles from Simla towards the "Interior." It is quite possible that this is the same species as that which I have just described as found in Simla, but it gives rise to very considerably greater distortions and hypertrophies in its host. The attacked plants were indeed extremely distorted: sometimes a whole flower head exhibited a mass of small æcidial tubes (Fig. 16, Pl. XV.), and individual leaflets when largely invaded exhibited the most curious forms (Fig. 17, Pl. XV.). In this form, sometimes, though not very frequently, the stalk also was affected. The æcidiospores are orange-yellow, and measured, when dry, 19 $\times$ 16 μ on an average, but, when well moistened, 22 $\times$ 18 μ.

It is possible that both these forms are identical with, or varieties of, *Æcidium Thalictri flavi*, D. C., the æcidiospores of which are said to measure 17 to 28 μ long and 14 to 20 μ broad.

9.—Æcidium Jasmini, nov. sp.

Jasminum humile, Linn.

An Æcidium may be found on this plant during July and August, but is decidedly uncommon. The parasite attacks both leaf and petiole, but more commonly the leaf blade, giving rise to an irregularly circular patch, slightly paled above, greenish yellow and brownish red below. These patches vary in size, but are usually about 8 m.m. to 1 c. m. in diameter. The involved areas of the leaf are slightly thickened. The æcidia burst out exclusively from the under surface of the leaf, so far as my observations extend. They contain brilliant orange-yellow spores, the peridium, a short tubular structure, bursting at the summit in a

stellate manner. Spermogonia exist only on the upper surface, preceding the appearance of the æcidia by a very short time—indeed, while ripe spermogonia exist on the upper surface of a patch, young unopened æcidia may also be found on the lower surface of the same patch.

The *mycelium*, which ramifies between the parenchyma cells, is colourless. The bases of the spermogonia extend to the inner level of the palisade cells, and the bases of the æcidia from the other side reach down to the same point. The spermogonia measure about 126 μ in depth and 157 μ in breadth, and have a tuft of paraphyses projecting from the mouth to about 63 μ.

The *peridium* consists of a single layer of flat cells, more or less hexagonal and measuring about 26 × 22 μ (Fig. 2, Pl. XIV.). These cells are thick-walled and contain some yellow oil globules in their cavities.

The *æcidiospores*, after lying a few minutes in water, measured 26·2 × 20·2 μ on an average. Their contents are of a brilliant orange-yellow colour, and they have a thin epispore without any markings (Fig. 3, Pl. XIV.). I did not succeed in observing their germination, as they steadily refused to grow in water. The only other species of Jasmine common in Simla is *J. officinale*, L., but this host nevers bears an Æcidium, although the closely related *J. grandiflorum*, L., which grows at considerably lower elevations, harbours a very distinct and peculiar one, which I hope to describe later.

10.—Monosporidium Euphorbiæ, gen. et sp. nov.

Euphorbia cognata, Klotzsch.

Towards the end of July and during the first half of August, a very peculiar Æcidium on this plant presenting some very unusual characters is not uncommon; and some individual plants are very extensively attacked. Only the leaf blades are attacked, so far as I have observed, and a single leaf may exhibit from one to six patches of invasion. These patches are circular and rosy red above with a broad and irregular halo of paled yellowish tissue around them, the paling increasing in area as the patch grows older (Fig. 4, Pl. XIV.). On the under surface the patch is quite white and cushion like (convex). When very young, this cushion on the lower surface of the leaf is uniformly convex, and with a field lens a few pellucid spots may be seen in its centre, which are spermogonia. Later, as the spermogonia wither, a very distinct pit or depression is formed in the centre of the cushion, and, while this central pit enlarges in area, so the circular cushion surrounding it becomes more and more prominent and whiter. At last the central pit

s very distinct with now *black* points, the dried up spermogonia, over it (Fig. 4, Pl. XIV), and then the epidermis covering the surrounding cushion tears circularly near the external margin of the cushion and curls up inwards towards the centre disclosing a bed of white æcidiospores (*see* left-hand patch in Fig. 4, *a.* and *b.*). The *spermogonia*, which are extremely superficially placed (*see* Fig. 6, Pl. XIV.), are thus situated on the under surface of the leaf only. They are of the usual form and structure with a tuft of paraphyses protruding through the mouth. The whole organ, excluding the paraphyses, measures about 50 μ in depth and 100 μ in breadth. The *æcidiospores*, when just wetted with water, measure from 22 $\times$ 20 μ to 19 $\times$ 18 μ, the average of several measurements being 21 $\times$ 19·2 μ. The spores are colourless and almost round (Fig. 5, *a.* Pl. XIV.) with an epispore densely studded with minute tubercles. The distribution of the *mycelium* is peculiar and deserves description. In a section of a leaf passing through the æcidium, it will be seen that the mycelium lies mainly in two strands, one under the upper epidermis, between it and the palisade-cells, the other and larger under the lower epidermis, between it and the spongy cells (Fig. 6, Pl. XIV.). Moreover, the character of the layer of hyphæ under the upper epidermis is of a somewhat looser, more pseudo-parenchymatous character, than that under the lower epidermis (Fig. 7, Pl. XIV.). It should be noted that these layers of mycelial filaments are composed solely of hyphæ without any part of the host tissue being involved within them, and thus resemble strikingly the non-algal parts of lichens. The palisade-cells and spongy tissue between the two layers of mycelium are indeed extremely little affected or altered in any way. While in unaffected normal places the length of the palisade-cells is about 60 μ, and the depth of the spongy tissue layer about 50 μ, these measurements within attacked areas are about 56 μ and 36 μ, thus showing some diminution in size, especially in the spongy layer. The lower mycelial layer is about 50 μ in depth and the upper layer only 24 μ. The æcidial fructification is, as it were, inserted within the lower mycelial layer (*see* Fig. 6, Pl. XIV.), some strands passing above it and some below it. The *peridium* consists of a layer of cells about 32 $\times$ 30 μ in size, forming only a *roof* to the extremely large circular æcidium (*see* Fig. 6, Pl. XIV.). These cells are very loosely attached to one another, readily becoming isolated. Such an isolated cell is shown in Fig. 5, *b.* Pl. XIV ; and this figure also shows that it is beset externally with tubercles. The æcidiospores are given off in rows from a pseudo-parenchymatous hymenium without any well defined basidia, and have no intermediate cells between successive spores (Fig. 6, Pl. XIV.). The æcidiospores, as seen in rows in sections of leaves that have been hardened in absolute alcohol, are cubical (Fig. 6, Pl. XIV.).

The germination of these æcidiospores is very peculiar and unlike that of any other species with which I am acquainted, with the single exception of the æcidiospores of the Æcidium on another Euphorbiaceous plant *(Andrachne cordifolia)* described further on. I have not here, unfortunately, access to special memoirs on the development of individual Uredines, so that I am unable to state definitely that the mode of germination of these spores is altogether unknown, but, so far as I have been able to consult the works of others on this subject, I have not seen this mode described. The spores germinate fairly readily in water, throwing out the usual single germ-tube, measuring 5 μ in diameter (Fig. 7, Pl. XV.). After a time, from 24 to 48 hours, a secondary spore (sporidium ?) is formed at the end of the germ-tube, not upon any sterigma, but simply separated from the tube by a septum (Fig. 9, Pl. XV.). This secondary spore is round or oval, is double-contoured, and contains well defined granules in a mass of protoplasm (Fig. 9, Pl. XV.). They measure as a rule 14 μ in diameter. The day after the formation of this secondary spore, it germinates while still attached to the primary germ-tube, throwing out a secondary germ-tube which soon takes on a spiral form (Fig. 8, Pl. XV.). After this, the whole structure perishes, and I have not been able to determine its future history.

Remarks.—This Æcidium is evidently not *Æc. Euphorbiæ*, Gmelin, (or *Uromyces Pisi*, Pers.), as in this species the mycelium is described as pervading the whole plant or shoot, deforming all the leaves and preventing the formation of flowers on the shoots attacked. In the Æcidium above described, only local and well-defined areas of the leaves are attacked by the mycelium; the leaves are not altered in general shape, and the shoots bear flowers as usual. For much the same reasons this Æcidium is not *Uromyces scutellatus*, Lév., which also markedly deforms the leaves. It remains to consider its affinities with the genus Endophyllum and especially with *E. Euphorbiæ silvaticæ*, D. C., on *Euphorbia amygdaloides*, which is said to cause a well defined alteration in the leaves of the host, rendering them shorter and wider and somewhat fleshy, and discolouring them to a pale yellowish green colour. Moreover, this parasite has orange-yellow spores 16 to 26 μ long and 12 to 18 μ wide, whilst in the Simla Æcidium the spores are colourless or pale brownish and measure, as stated above, 22 $\times$ 20 μ to 19 $\times$ 18 μ. Moreover, the germination of the æcidiospores of the last mentioned Æcidium is different from that described in the case of Endophyllum, which is essentially of the nature of the germination of teleutospores. There is, however, some resemblance between the two Æcidia in this respect, for we may consider the secondary spore of the

Simla Æcidium to be of the nature of a sporidium, and then the only difference that exists between them is that, whilst in Endophyllum four deciduous sporidia are formed on sterigmata, in the Simla parasite only one non-deciduous one is produced directly at the end of the promycelium instead of at the end of a sterigma. But these differences are still great enough, I think, to entitle the species to be regarded as the type of a very distinct group of the Æcidiomycetes having its closest affinities with the genus Endophyllum. The only other Æcidium with which I am acquainted that would find a place in this new group or genus would be that which I have described further on on *Andrachne cordifolia.* I would define the characters of this new (provisional) genus as follows :—

MONOSPORIDIUM, gen. nov.

Spore layer very like, or identically the same as, that of the Æcidia of Puccinia and Uromyces. The spores are abstricted in rows, but behave in germination somewhat like teleutospores in that the germ tube (promycelium ?) produces a secondary non-deciduous spore (sporidium ?) directly at its extremity without the intervention of a sterigma.

11.—PUCCINIA GRAMINIS, Pers.

Berberis aristata, D.C.

During August, the Barberry may frequently be found attacked by an æcidium-bearing parasite. Only the leaves are attacked, and, on them, circular patches are formed, almost crimson-red on the upper surface with a narrow halo of pale yellow-green (Fig. 3, Pl. XV) and pale rosy red below with pale yellow æcidia thickly strewn over it. A single leaf may contain from one to six or eight such patches. A medium-sized patch measures from 4 to 5 m.m. in diameter (including the halo of yellow), but sometimes the patches exceed 1 c. m. in diameter. With a field lens, numerous spermogonia may be seen on the upper red surface, but also a few in the centre of the lower surface, around which the æcidia are arranged.

The *æcidiospores*, when just moistened, measure from 22 × 17 μ to 20 × 18 μ, or, on an average, 20·8 × 17·8 μ. The contents are bright orange-yellow, and usually on one side of the spore a colourless space is left filled apparently with colourless protoplasm (Fig. 8, Pl. XIV) giving a characteristic appearance to the spores. The peridial cells are generally square in outline and measure about 20 × 18 μ (*see* Fig. 9, Pl. XIV.). They are thick-walled, thicker on one side (Fig. 10, Pl. XIV.), and contain orange-yellow matter in their centres.

When invaded by mycelium, the leaf is generally considerably

thickened, and the cells of the host are filled densely with starch grains. The *spermogonia* are situated mostly on the upper surface of the leaf, though some are borne also on the under surface. They are of the usual structure, well sunk into the tissue of the host, and with a tuft of paraphyses protruding from their mouths. These organs generally measure about 0·198 to 0·151 m.m. in depth and 0·138 to 0.126 m.m. in width, the tuft of paraphyses measuring about 75 μ in length.

Remarks.—There can be no doubt, I think, that this is identical with *Puccinia Graminis* as described by De Bary, although I have not confirmed its genetic relationship with the Puccinia on cereals which occurs very abundantly in all the fields around Simla. I am also not quite certain that all the three forms of Berberis which occur in Simla (namely, *B. vulgaris*, L., and *B. Lycium*, Royle, in addition to that already mentioned) bear the same species of Æcidium. The subject is one which requires further investigation and I will therefore leave it at present an open question.

12.—Æcidium Urticæ, Schum., var. Himalayense.

Urtica parviflora, Roxb.

I have described the life-history of this remarkable and very common Æcidium elsewhere,* so it is only necessary here to state briefly its characters. The parasite gives rise to remarkable hypertrophies of the tissues of the host invaded, usually the leaves and petioles, though frequently also the stems. When attacking the leaves, it has a special proneness to invade the main veins; and, by causing very great hypertrophy in them, gives rise to remarkable contortions. When it attacks the stem, it usually produces well defined comparatively large tumours or excrescences. The parasite is usually found in its fullest development during July. The hypertrophy of the parts invaded is due mainly to the increased size of the parenchyma cells, which are stored with nutritive material, and, to a very subordinate extent, to mycelial invasion. The mycelium penetrates some of the parenchyma cells forming haustoria of the branched type.

The *spermogonia* measure about 0·178 m.m. in depth and breadth with a tuft of paraphyses 68 μ long.

The æcidiospores are contained in a *peridium* of a single layer of flattened polygonal cells measuring on an average 20 μ in diameter. The *æcidiospores* are given off in long rows from basidia arranged very regularly on a level base. They are yellow round bodies with finely granular contents and beset externally with minute deciduous

* "Scientific Memoirs by Medical Officers of the Army of India," Part II. Calcutta, 1887.

tubercles. The moistened spore measures on an average 15·6 × 13·1 μ. The life-history of this æcidium is completed on *Carex setigera*, Don. The uredospores on this second host measure from 19·8 × 13·5 μ to 19·2 × 12·8 μ. The teleutospores (puccinia) are 56 μ long by 15 μ broad on an average. The upper cell measures 24 to 20 μ in length by 12 to 17 μ in breadth, whilst the lower cell varies from 20 to 14 μ in length and 12 to 14 μ in breadth. In germinating, each cell forms a promycelium which divides at its end into four compartments each forming a sporidium at the end of a slender sterigma. The sporidia measure 12 × 8 μ. For further particulars I must refer to the paper already alluded to.

13.—Æcidium Strobilanthis, Barclay.

Strobilanthes Dalhousianus, Clarke.

The Æcidium which occurs on this plant is probably the most common and widely diffused in Simla. I have described its life-history fully in a paper in "Scientific Memoirs by the Medical Officers of the Army of India"*, to which I would refer those who desire further information, while here I will only note its main characters. The parasite may be found abundantly during July and August attacking only the leaf-blades and very rarely indeed the petiole. The leaves are often found very extensively bespattered with circular discoloured patches, yellow or yellowish green above and rosy or purplish or yellow below. The patches usually measure about 4—5 m.m. in diameter, but sometimes more, and are usually slightly concave above. The spermogonia are borne on the upper surface and may be recognised as minute points. The æcidia are borne on the lower surface. The invaded areas are considerably thickened, the thickening being due mostly to hypertrophy of the spongy cells and to a lesser extent to that of the palisade-cells. The mycelial filaments are of the usual characters and form here and there simple tubular haustoria.

The *peridium* consists of a single layer of flattened angular cells measuring on an average 16·3 × 11·6 μ. The *æcidiospores* are given off in rows, as usual, without intermediate cells. They are irregularly round pale orange-yellow and measure, when just moistened, 18 × 16 μ.

The *spermogonia* measure about 100 μ in depth by 94 μ in width. They are formed both on the upper and on the lower surface of the leaf, but more frequently on the upper. They have a tuft of paraphyses protruding through their mouths about 80—90 μ.

This fungus completes its cycle of development on *Pollinia nuda*,

* "Scientific Memoirs by the Medical Officers of ihe Army of India," Part II. Calcutta, 1887.

Trin. The uredospores on this last mentioned host measure, when just wetted, 21·6 × 20·2 μ. The teleutospores (puccinia) on the same measure 36 μ in length by 16 μ at the septum. The septum divides the spore into two equal halves. The promycelia from each cell divide at their ends into four cells, each of which produces a sporidium at the end of a slender sterigma. The sporidia measure from 10 × 6 μ to 12 × 7 μ.

14.—Gymnosporangium clavariæforme, Jacq.?

Pyrus variolosa, Wall.

An Æcidium (Roestelia) on this single species of the several members of the Pomaceæ in and about Simla is fairly common from May to August: but I have observed in this case, as in several others, that in some years it is more common than in others. For example, in 1885, I found no difficulty in obtaining as many specimens as I desired: in 1886, I experienced the greatest difficulty in finding a very few, while now, in 1887, it is again fairly common, though not so common as in 1885. It attacks only the leaf-blades and no other parts, so far as my observations have extended, forming well defined patches, orange-red above and yellowish below, the upper surface being densely studded with spermogonia. Generally the fully developed older dark green leaves bear these æcidial patches, the younger paler leaves being only exceptionally attacked and these late in the season, namely, in July, The area of the leaf blade invaded varies in extent from a few millimeters in diameter to 1 c. m. or even a little more, and is considerably thickened. While the thickness of the normal leaf blade is about 0·170 to 0·190 m.m., the attacked parts when æcidia are developed measure about 0·880 m.m. The thickening of the leaf blade is due mostly to an apparent proliferation of the spongy tissue cells, which are also altered in form, becoming long palisade-like cells instead of irregularly round as under normal conditions. The true normal palisade-cells are about 44 μ in length, whilst the transformed spongy cells are 63 to 107 μ in length. The mycelium ramifies throughout the cells of the attacked areas.

The æcidia are very deeply sunk, long tubular structures, the portion sunken beneath the level of the epidermis being about 0·756 m.m. in length and about 0·190 m.m. in diameter. Each æcidium is situated on a minute papilla and is extruded only from the under surface of the leaf, never from the upper. That portion of the æcidial fruit which projects freely beyond the level of the epidermis is about 1 to 2 m.m. in length.

The *peridium* consists of a single layer of cells, the lower ones being more elongated than the upper. Those situated about the middle

measure about 70 × 22 μ, and all are beset with prominent rod-like excrescences (Fig. 5, Pl. XV.). When the æcidium is ripe, the peridium bursts longitudinally in strips from summit to base.

The *æcidiospores* are round or oftener oval, measuring, when just wetted, 28·6 × 24·6 μ on an average. They are pale brown in colour and their surfaces are beset with minute tubercles (Fig. 6, Pl. XV.).

The *spermogonia* are formed only on the upper surface of the leaf, and when ripe have a sticky clear fluid over them probably secreted by the tuft of paraphyses, which, arising from the very base of the organ, project considerably (about 50 to 60 μ,) from the mouths. They are well sunken into the tissue of the leaf, their bases pushing down and disintegrating the palisade-cells. They remain covered over by the cuticle until ripe, when the cuticle is raised and opened by a porous opening. The formation of the spermogonia precedes that of the æcidia by a very considerable length of time. In the spermogonial stage, the hypertrophy of the leaf tissue is not so great as it becomes later, the thickness of the lamina being about 0·41 m.m. If sections of the leaf through a spermogonium be stained with Spiller's purple, it will be found that, while the sterigmata are coloured blue, the spermatia are coloured brick-red. The spermatia are oval and measure 8 × 4 μ.

Remarks.—From the nature of the dehiscence of the peridium, there can be no doubt that this Æcidium is identical with or allied to *Gymnosporangium clavariæforme*, Jacq., though in some respects it is not unlike *G. juniperinum*, L., especially in the colour of the spores. I made very frequent and numerous attempts to reproduce this Æcidium with teleutospores from a Gymnosporangium on *Cupressus torulosa* which is by no means uncommon on the few trees which occur in Simla, but always without result. Notwithstanding these negative results, I am still, however, inclined to believe that this Gymnosporangium (the only one I am acquainted with in these parts) is genetically related to the Æcidium just described, and I attribute my negative results to the influence of some unknown condition attending my experiments, although I have varied the conditions in every conceivable manner.

15.—Monosporidium Andrachnis, gen. et. sp. nov.

Andrachne cordifolia, Müll. Arg.

During August, especially towards its latter end, an Æcidium is not unfrequently met with on this host, which is common at elevations a little below that of Simla. It is not, however, a common Æcidium. Only the leaves are attacked and on them circular patches are formed by the fungus, red above with an irregular halo of

yellow around it (Fig. 2, Pl. XV) and pale rosy red beneath (Fig. 1, Pl. XV.). The patch is concave on the upper or red surface, the under surface being correspondingly convex, and on this latter surface only are the Æcidia produced. Generally only one patch is to be found on a single leaf, though I have seen as many as six. The patches are usually very uniform in size, generally measuring about 6 m.m. in a diameter. The centre of the under surface of the patch is occupied by a number of spermogonia, while around it the æcidia are grouped more or less irregularly. A few spermogonia, however, emerge from the upper surface also. This Æcidium, therefore, in its general characters already resembles that described above on *Euphorbia cognata*, but differs notably in the æcidia being isolated cups, whilst in Euphubia we may imagine that the several cups have all fused together into one large circular æcidial fruit. The peculiar arrangement of the mycelium, however, in layers so characteristic of *M. Euphorbiae* is not found here. The mycelium ramifies generally among the cells as in other æcidia. The palisade-cells are not disarranged or deformed in any way, but the spongy tissue cells are hypertrophied and proliferated. The thickness of the leaf where invaded and where ripe aecidia were borne was in one instance 0·334 m.m., whilst the normal thickness was 0·138 m.m. The spermogonia are very small and superficial, as in *M. Euphorbiae*. They are insinuated between the epidermis cells and measure about 44 μ in width and 25 to 30 μ in depth. The æcidia when fully ripe measure about 0·265 to 0·248 m.m. in width and 0·233 to 0·217 m.m. in depth.

The *æcidiospores* are round, oval (Fig. 11, Pl. XV.), colourless, or very pale brown, and measure, when just wetted, on an average 21·6 $\times$ 18·4 μ, varying from 20 $\times$ 16 to 24 $\times$ 20 μ. They are given off in rows without any intermediate cells. The peridial cells are flat and irregular in shape, imbricate in arrangement, and measure from 18 to 24 μ in diameter (Fig. 10, Pl. XV.). They are beset with small ridges or tubercles. The mode of germination of these æcidiospores is exactly like the peculiar germination of the spores of *Monosporidium Euphorbiae*. The spores germinate very readily in water, throwing out a long non-septate tube, when the empty spore wall is seen to be beset very densely with minute tubercles. After lying in water 24 to 36 hours, a secondary spore is formed at the extremity of the germ tube (Fig. 13, Pl. XV.) just as I have described it in the case of Euphorbia. This secondary spore or sporidium is separated off from the germ tube by a septum, but never falls off altogether from the tube. In a cultivation of 48 hours' duration, I saw numerous secondary spores, and several of them, while still attached, had commenced to germinate,

throwing out narrow tubes, which, though twisted a little (Fig. 14, Pl XV.), never became spiral as in the case of *M. Euphorbiae*, nor so long. These secondary spores measure from 18 × 15 μ to 22 × 16 μ and on an average 20·3 × 15 μ. They are double-contoured and contain large granules in their protoplasm.

16.—Æcidium Compositarum, Martins.

Myriactis nepalensis, Less.

I have never found this Æcidium actually in Simla, where the host is common, but at Mashobra, a few miles beyond the Station, at about the same elevation. It may be found there towards the end of August and beginning of September. Only the lower leaves are affected, and generally before the plant sends up its flowering stalk, though I found one plant with three of its lower leaves affected while it was in full flower. The patches are circular and usually single, but sometimes more, on each leaf, and they are very large, measuring about 1·5 c. m. in diameter. The upper surface is pale yellow with a dark discoloured centre as the patch becomes older, while the lower surface is very pale yellow and here the æcidia are borne in great numbers thickly set together. With a field-lens it may be seen that the spermogonia are borne on the upper surface quite on the *margin* of the patch and not within it.

The *æcidiospores* are irregularly round or oval, pale yellow, and, when just wetted, measure from 14 × 14 to 17 × 12 μ and on an average 16 × 15·2 μ. (Fig. 15, *a.*, *b.*, Pl. XV.). The spores are given off in rows as usual. The epispore is thin.

The peridial cells measure about 34 × 16 μ to 42 × 20 μ and are arranged in an imbricate manner (Fig. 15, *c.*, *d.*, Pl. XV.).

Remarks.—The Æcidium not occurring actually in Simla, so far as I am aware, I have not been able to pay special attention to it. I presume it may be included under *Æcidium Compositarum*, Martins, although the measurements I give of the æcidiospores are smaller than those given by Winter in the case of *Puccinia flosculosorum*, Alb. & Schw., and *Uromyces Junci*, Desmaz. However, as I do not know of any teleutospore belonging to this Æcidium, I cannot do better than refer it provisionally to *A. Compositarum*, as recommended by Winter.

Concluding Remarks.—This completes the list of æcidium-bearing Uredines I have hitherto been able to examine in Simla, with the exception of the five which occur in Coniferæ, and which I hope to describe in a future paper. Three of these (on *Abies Smithiana* and *Cedrus Deodara*) I have already described in this Journal.* The other two occur on *Pinus longifolia* and *P. excelsa*.

* J. A. S. B. 1886, vol lv, pt. ii, pp. 1—11, pls. i—iii; pp. 140—143, pls. iii, iv; et pp. 223—226, pls. vi, vii.

In addition to these, I have seen Æcidia on a species of *Geranium* (probably *nepalense*) and on *Ranunculus diffusus*, but in each case I only once found specimens, and unfortunately in each case I was unable to examine them. They are extremely rare about Simla. I may here also note that a very interesting Æcidium occurs on *Jasminum grandiflorum*, L., whose life history I am now engaged in investigating, but it is confined to the low-lying valleys near Simla and never appears in the station, which is too high for the host. A nearly allied species (*Jasminum officinale*, L.) which occurs abundantly in the woods about Simla never harbours this parasite or that which I have described above on *Jasminum humile*.

DESCRIPTION OF THE PLATES.

Plate XII.

1. Sanicula : æcidiospore, × 350.
2. Ditto : peridial cells, × 350.
3. Pimpinella : uredospore, × 350.
4. Violet : leaf, lower surface, natural size.
5. Ditto : leaf, upper surface, natural size.
6. Ditto : æcidiospore, 24 hours in water, × 250.
7. Ditto : promycelium, × 350.
8. Ditto : ditto.
9. Ditto : ditto : showing terminal sporidial formation, × 350.
10. Ditto : germinating sporidium, × 350.
11. Ditto : peridial cells, × 400.
12. Valeriana : æcidiospore, × 580.
13. Ditto : uromyces spore, × 580.
14. Pimpinella : æcidiospore, × 350.
15. Ditto : peridial cells, × 350.

Plate XIII.

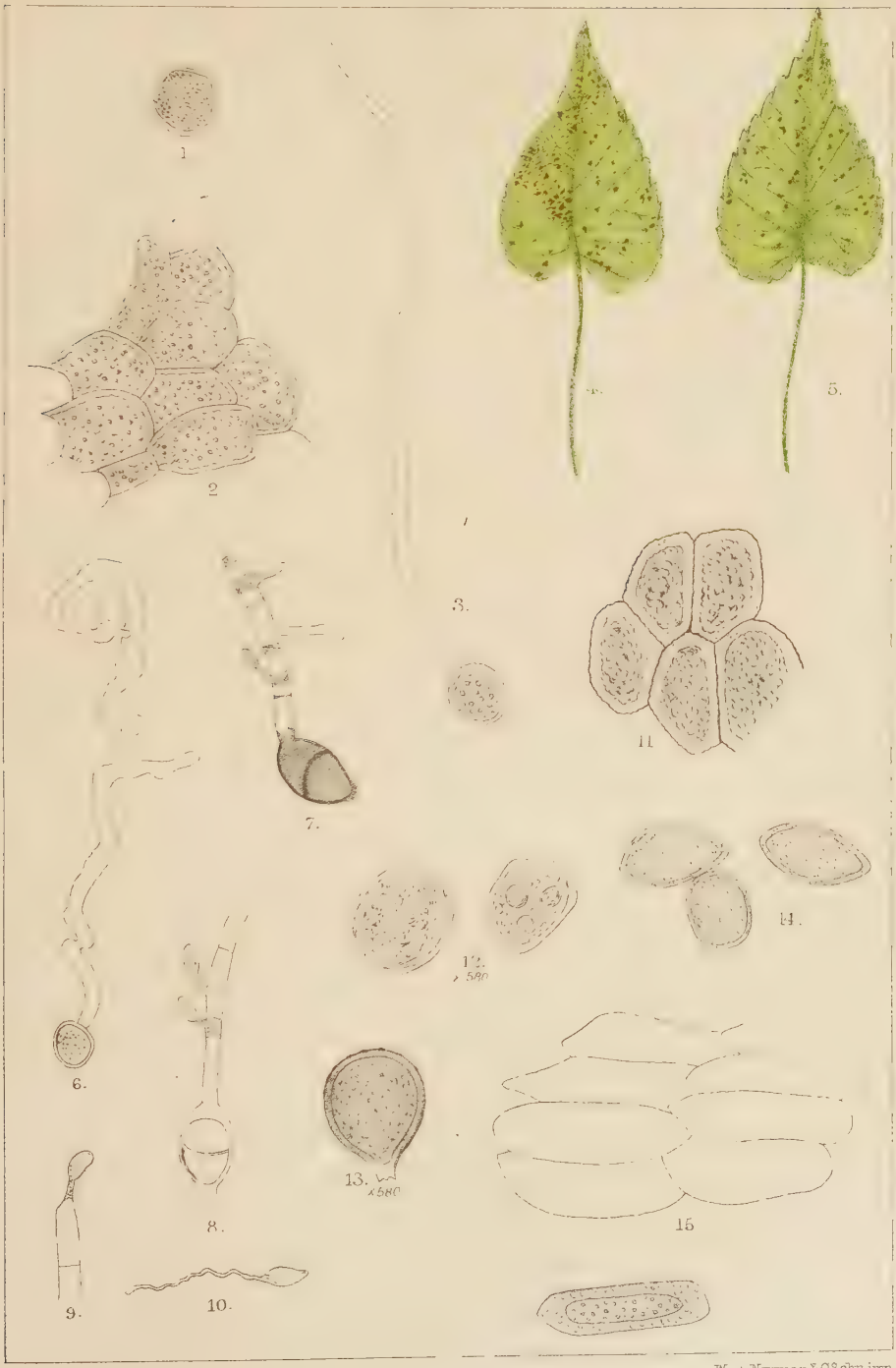
1. Rhamnus : leaf, lower surface, natural size.
2. Ditto : ditto, upper surface, natural size.
3. Ditto : stem attacked, natural size.
4. Ditto : peridial cells, × 350.
5. Ditto : æcidiospore, × 350.
6. Fragaria : æcidiospore, × 350.
7. Ditto : uredospore, × 350.
8. Ditto : germinating uredospore, × 350.
9. Ditto : teleutospore, × 350.
10. Valeriana : æcidiospore, × 400.
11. Anemone : outline of leaf showing attack : natural size.
12. Ditto : æcidiospore. × 480.
13. Thalictrum : peridial cells, × 350.
14. Ditto : æcidiospore, × 350.
15. Ditto : basal cells of a row of æcidiospores showing intermediate cells, × 480.

Plate XIV.

1. Thalictrum : portion of shoot showing petioles attacked, natural size.
2. Jasminum : peridial cells, × 350.
3. Ditto : æcidiospores, × 350.
4. Euphorbia : *a.* leaf, natural size.
   b. same somewhat enlarged.
5. Ditto : *a.* æcidiospore, × 350.
   b. peridial cell, × 350.
6. Ditto : transverse section of leaf showing peculiar disposition of mycelium and superficial nature of spermogonium.
7. Ditto : *a.* layer of mycelial filaments on lower side of leaf ; *b.* same on upper side, × 480.
8. Berberis : æcidiospore, × 350.
9. Ditto : peridial cells, × 350.
10. Ditto : two isolated peridial cells, × 350.

Plate XV.

1. Andrachne : under surface of affected leaf, natural size.
2. Ditto : upper surface.
3. Berberis : upper surface of attached leaf, natural size.
4. Berberis : peridial cells, × 350.
5. Pyrus : peridial cells, × 350.
6. Ditto : æcidiospores, × 350.
7. Euphorbia : æcidiospore germinating, × 350.
8. Ditto : germinating æcidiospore, showing formation of secondary spore (sporidium) and its germination while *in situ*, × 350.
9. Ditto : secondary spore (sporidium), × 350.
10. Andrachne : peridial cells, × 350.
11. Ditto : æcidiospores, × 350.
12. Ditto : showing end of germinal tube (promycelium ?) of æcidiospore with commencing formation of secondary spore or sporidium, × 350.
13. Ditto : completely developed secondary spore, × 350.
14. Ditto : showing germination of secondary spore (sporidium) 350.
15. Myriactis : *a.* row of æcidiospores ; *b.* isolated spore ; *c.* and *d.* peridial cells, × 350.
16. Flower head of *Thalictrum minus* completely involved and distorted by the Æcidium, natural size, approximately.
17. Leaf of same. Leaf deeply hollowed, much enlarged and thickened, and covered profusely with æcidia outside with a few tubes also inside natural size, approximately.

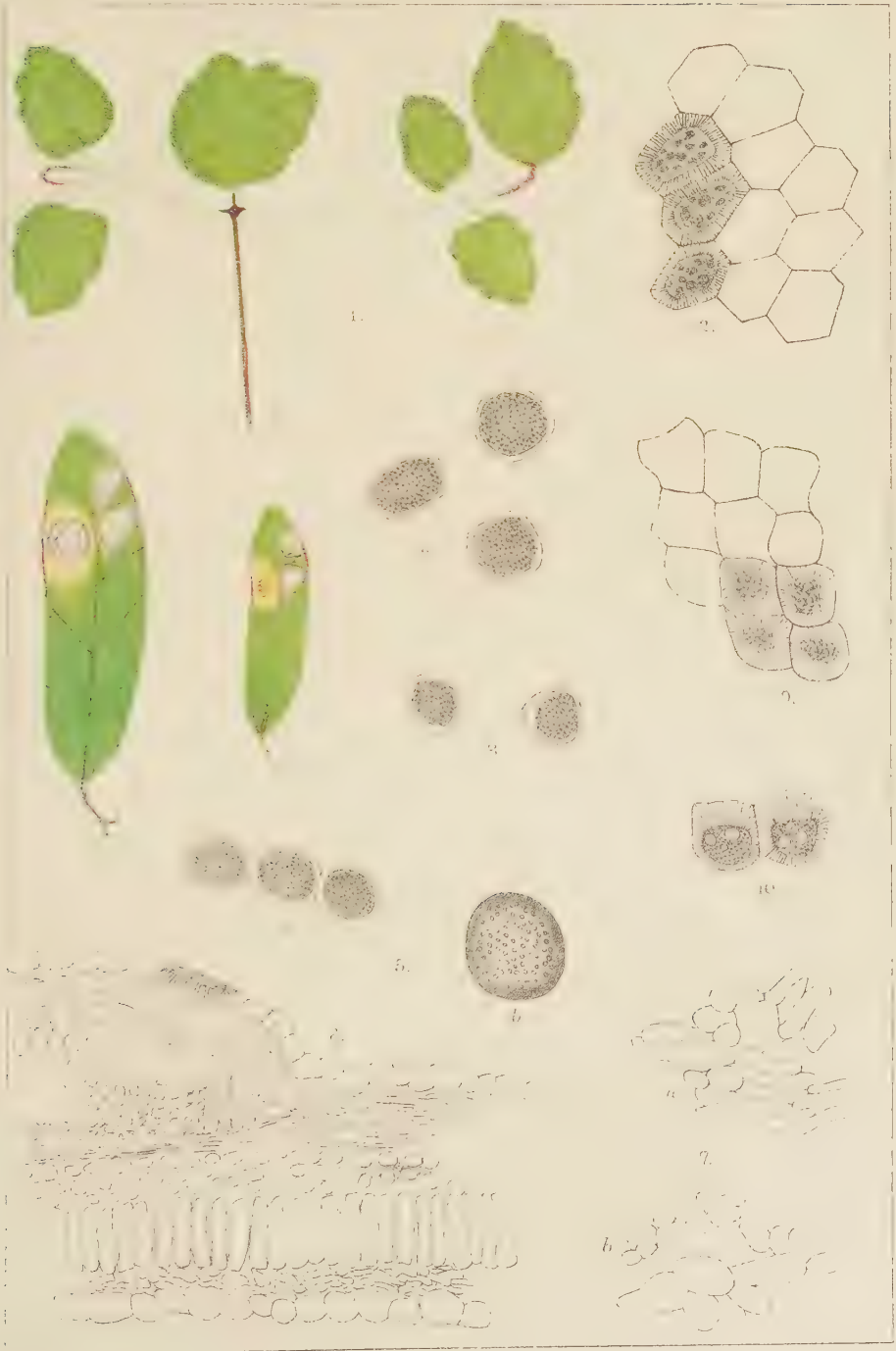


A. Barclay, del.
Parker & Coward, lith.

West, Newman & Co. chr. imp.

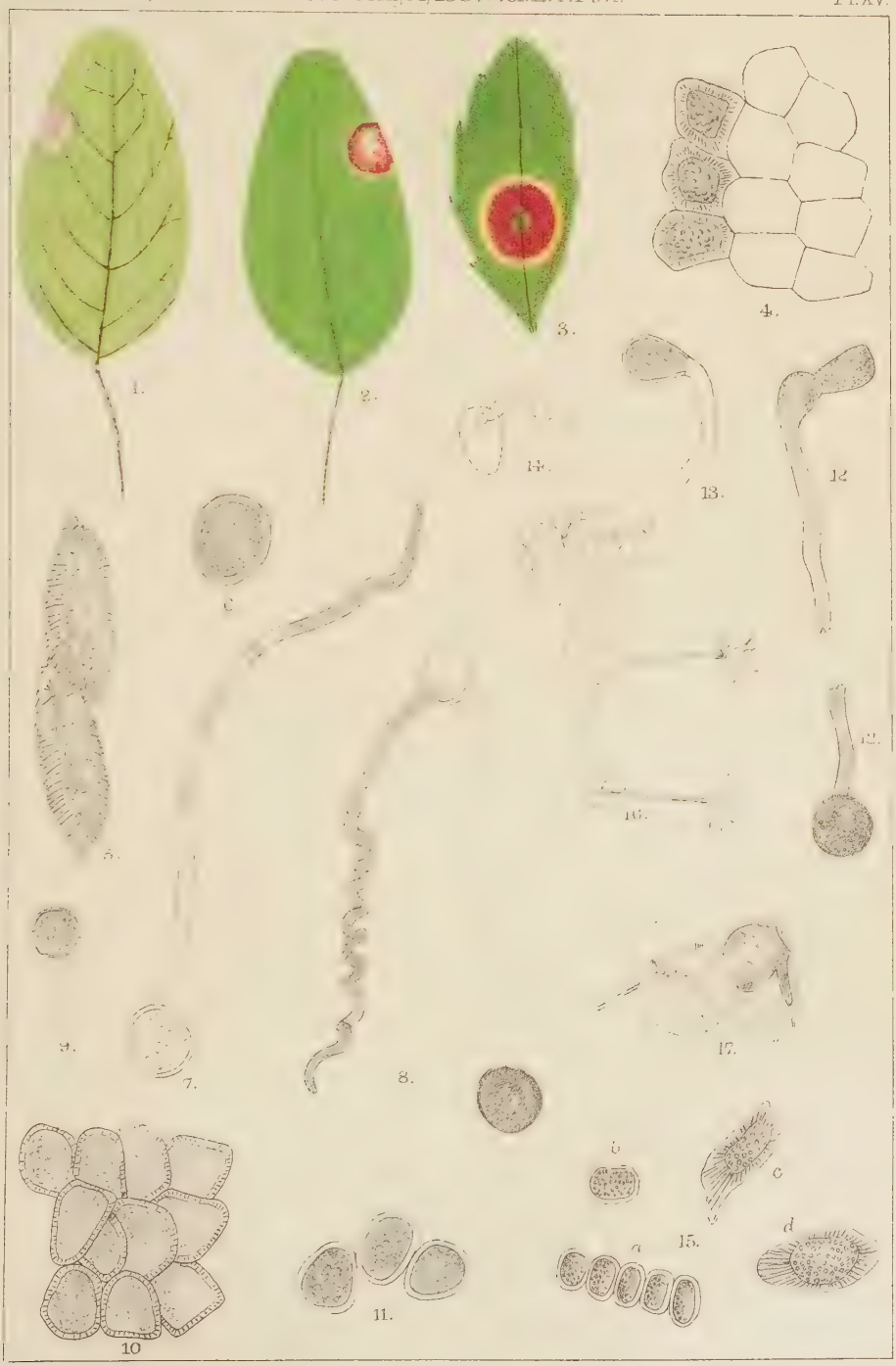
A. Barclay, del.
Parker & Coward, lith.

West, Newman & Co. chr. imp.



A. Barclay, del.
Parker & Coward, lith.

West, Newman & Co. chr. imp.



A. Barclay, del. West, Newman & Co° cmc. imp
Bagley & Gerrard, lith.

A

DESCRIPTIVE LIST

OF THE

UREDINEÆ

OCCURRING IN THE

NEIGHBOURHOOD OF SIMLA (WESTERN HIMALAYAS).

PT. II. PUCCINIA.

BY

A. BARCLAY, M. B.,

BENGAL MEDICAL SERVICE.

[*Reprinted from the Journal of the Asiatic Society of Bengal, Vol. LVIII, Part II, No.* 2, 1889.]

CALCUTTA:

PRINTED BY G. H. ROUSE, AT THE BAPTIST MISSION PRESS.

1889.

A Descriptive List of the Uredineæ *occurring in the Neighbourhood of Simla (Western Himalayas).* Pt. II. Puccinia.—*By* A. BARCLAY, M. B., *Bengal Medical Service.*

[Received 27th March ;—Read 3rd April, 1889.]

(With Plates XII., XIII., & XIV.)

In this second instalment of a descriptive list of the *Uredineæ* of Simla (commenced in this Journal, Vol. LVI, Pt. II, No. 3, 1887), I propose giving the characters of all the *Puccinia* with which I am acquainted, dividing them artificially into two classes, (*a*) those occurring on hosts other than the grasses (and sedges), and (*b*) those on the grasses and sedges. The former list is, I believe, fairly complete, but doubtless many additions will be made in future to the latter. These fungi on grasses are often so inconspicuous that they readily escape even trained observation.

I had hoped to have completed the list of Æcidial forms by describing those on the *Coniferæ*, one on *Jasminum grandiflorum*, L., and another on *Geranium*, sp., before proceeding to the teleutosporic forms; but, as I must delay the publication of a description of the former until I shall have filled up certain gaps in my notes of them by further observation, I think it better to proceed with the other forms rather than to delay the whole series, more especially as my recent absence from India for a year has already interfered with work too long.

In the list now given, sixteen species are described in the first list, of which three, I believe, are new; and nine in the second list, of which four are perhaps new. In the case of those species which occur on grasses, it is extremely difficult to decide which should be considered new, and which should not. Any classification of them must remain extremely imperfect until their life-histories are known. Of the new species in the first list, that which I have named *Puccinia Rosæ* is interesting in giving rise to a powerful odour, and in possessing an all-pervading mycelium in the shoots attacked. *P. Galii*, Pers., exhibits an instance of very unusally long retained power of germination in the uredospores. *P. Rubiæ* appears to be a complete autœcious Uredine in which æcidial fructification has dropped out.*

I have arranged the species in List I. under group headings *Leptopuccinia*, *Micropuccinia*, &c., as is done by Winter in his work†; but I

* As this paper was passing through the press, I have been able to confirm this, and further details will be found in 'Scientific Memoirs by Officers of the Army of India', Part V.

† Die Pilze Deutschlands, &c.

have not attempted the same subdivision in List II., because I am by no means sure that uredospores are not produced in those cases in which I do not happen to have found them.

List I.

a. (Leptopuccinia).

1. Puccinia Rosæ, nov. sp.

on *Rosa macrophylla*, Lindl.

This curious fungus does not occur in Simla, but is abundant at Narkanda, some forty miles distant from Simla towards the interior. It is curious in several respects. In the first place the mycelium pervades the whole of the tissues of the shoots attacked, and almost every leaf in such a shoot bears spores. The affected shoots are paler in colour than normal and somewhat hypertrophied.

All attacked leaves are discoloured and much smaller and thicker than the normal ones. The diminished size is due to the fact that apparently only the young leaves are attacked and, when attacked, are arrested in growth. Another peculiarity in this fungus is that, when the spores are formed, the whole affected part of the plant has a most offensive fœtid smell, which I can only compare with the smell of the stalk of flowers of certain *Arisæma*. It is a smell which suggests the attraction of flies to the part; but I never actually saw flies thus attracted. The only other *Puccinia* emitting a powerful odour with which I am acquainted is *P. suaveolens*, (Pers.), and this fungus likewise gives rise to deformity in the host's tissues. The fungus is so far away from Simla that I have had no opportunity for closely studying it. The mycelium appears to be perennial, but I have not been able to prove this. The teleutospore pustules are large, brown, and powdery, the spores being very deciduous, breaking off from their beds with only a fragment of stalk adhering to them. This fungus is met with in May and June: after that the parts bearing the fungus wither.

The spores when examined by transmitted light are orange-red, falling off readily from their beds with generally only a small fragment of stalk adhering. The spores measure about 36 μ in total length, and 18 to 22 μ in width at the septum. The epispore is very characteristically marked by longitudinal, or more frequently oblique, striation passing continuously over both cells, giving the spore a twisted appearance somewhat like the ovary of orchids. These striæ are interrupted ridges, as may readily be seen in empty spores after germination (Figs. 6, 7, Pl. XII). Placed in water they germinate readily immediately after ripening. The upper cells germinate first usually. The yellow contents of the spore wander

into the germ tube. The promycelium divides into four compartments, but usually only the distal three bear sporidia, though occasionally all four do so. Sterigmata are formed at the middle of the compartments, excepting in the case of the terminal cell, where the sterigma is terminal. The promycelium of the lower cells emerges from a point near the septum. The sporidia measure 10 μ in diameter.

2. Puccinia Urticæ, Barclay.

on *Urtica parviflora*, Roxb.

I have described this *Puccinia* elsewhere,* but will here briefly recapitulate its characters. The leaves in autumn (October) often bear numerous pustules on the under surface, varying from the size of an ordinary pin's head to 3 mm. in diameter. These pustules are very convex towards the under surface of the leaf with a corresponding concavity above. The invaded areas are at first pale yellow both above and below, but afterwards become brown below and orange yellow with a pale green margin above. The pustules consist of aggregations of minute circular prominent spore beds The spores are firmly adherent, brown, thickened at the apex, and vary greatly in size and shape (Fig. 9, Pl. XII). One of average size measures 40 μ in total length (upper cell 18 μ and lower 22 μ) and 17 μ in greatest breadth. Double-headed spores are not uncommon. They germinate immediately after ripening in water, throwing out promycelia in 24 hours, the upper from the apex and the lower from a point near the septum. The sporidia measure 12 × 8 μ. No uredospores are ever formed so far as my observations extend. This *puccinia* has no connection whatever with the life history of the well known *Æcidium Urticæ*, Schum.

3. Puccinia Saxifragæ ciliatæ, nov. sp.

on *Saxifraga ligulata*, Wal., var. *ciliata*, Royle.

This, so far as I am aware, is an uncommon parasite, and I have found it only in two localities. In one place, I found it in July, in the other, as early as the end of February. An attacked leaf displays a large number of minute dark chesnut-brown pustules about the size of an ordinary pin's head, always on the lower surface, each surrounded by a conspicuous yellow zone (Fig. 7, Pl. XIII). The unburst pustules are of a pale rosy yellow colour. They are very irregularly scattered over the surface of the leaf, and their positions beneath are indicated above by red spots. The spore beds are well raised and hemispherical. The spores are light brown

* *Æcidium Urticæ*, Schum., var. *Himalayense*, 'Scientific Memoirs by Medical Officers of the Army of India' 1887, Part II, p. 38.

and firmly adherent to their beds, breaking off with a long piece of the stalk adhering (70 μ long in one case measured). Each cell has a clearly defined nuclear space (Fig. 8 *a*, *b*, Pl. XII). The free end of the spore is considerably thickened and pointed. The spore is elongated, spindle-shaped, well constructed at the septum, and narrowing at both ends (Fig. 8, Pl. XIII.) The whole spore measures when moist from 51—65 μ in length, the upper cell from 26—36 μ in length by 16 μ in greatest breadth, and the lower from 25 — 31 μ in length by 14 μ in greatest breadth. The septum measures 11 — 12 μ in breadth and the thickening at the free end 6—11 μ in depth. After lying 24 hours in water some spores germinated throwing out short promycelia with colourless contents. The upper promycelium emerges from a point to one side of the apex, and the lower from a point near the septum. They did not go on to the formation of sporidia.

Remarks.—These characters do not agree with those given by Winter,* for *P. Saxifragæ*, Schlechtd., or *P. Adoxæ*, D. C. In the former case, the teleutospore pustules are aggregated together in irregular and variously coloured areas (seldom isolated), and the spores are deciduous and much smaller than those of the Simla species. The teleutospore beds of *P. Adoxæ* likewise coalesce, and the spores are deciduous and considerably smaller (30—45 μ long). In one point, however, there is a resemblance: in both the free end has often a pale lengthened thickening or projection. But, as *P. Adoxæ* is an autœcious *Eupuccinia*, I am inclined to regard the Simla species provisionally as distinct.

4. Puccinia Circææ, Pers.

on *Circæa alpina*, Linn.

This fungus is met with at higher elevations than Simla, namely, about 9000 feet. I found it occurring plentifully in the forests near the "Chor" mountain. Each attacked leaf usually displays numerous dark brown pustules on its lower surface (50 and more) varying in size from a minute point to 1 to 2 m. m. in diameter, and each surrounded by a zone of discolouration. Examined with a lens each pustule is seen to consist of numerous minute hemispherical beds aggregated together. The teleutospores are firmly adherent and when scraped off become detached with a long piece of stalk adherent and usually come off in masses. The spores are very small, brown, elongated, constricted at the septum, much thickened at the free end with the lower cell narrowing towards the stalk (Fig. 11, Pl. XIV). The free end is more or less pointed. Herbarium specimens of spores when moistened measure from 30 to 32 μ in total length (the upper and lower cells being usually equal in length)

* Loc. cit.

and 7 to 9 μ in width at the septum. The apical thickening is 6 to 7 μ in depth.

Remarks.—This fungus is probably identical with *P. Circææ*, Pers. I only once visited the locality where it occurs, in October, and do not know therefore whether earlier spores of a somewhat different character are formed as is the case with *P. Circææ*.

b. Micropuccinia.

5. Puccinia Geranii silvatici, Karsten.

on *Geranium nepalense*, Sweet.

During April to June I have on several occasions found this plant attacked by a *Puccinia*-bearing mycelium with this peculiar character that, when it attacks the stem, as it frequently does, it gives rise to very considerable hypertrophy of the host's tissues. The fungus is by no means a common one and usually attacks the leaf blades, distorting and crumpling them (Fig. 10, Pl. XII), and forming spore beds in little dark reddish brown pustules on the under surface. A few isolated pustules occasionally open on the upper surface. The pustules are aggregated together in patches of various size, but generally large, sometimes involving half the whole surface of the leaf. On the leaf, the individual pustules are so closely packed together that a superficial examination would induce one to believe that the whole patch is one large spore bed. When the stem or petiole is attacked, the individuality of each pustule is more marked probably because of the hypertrophy always attending such cases In one specimen I found the fungus had attacked a node of the stem where three shoots were given off, causing great hypertrophy (Fig. 11, Pl XII) with pale rosy discoloration of the superficial tissues. Petioles were often found attacked and hypertrophied. The pustules on the stem and petioles were often oblong or linear. The mycelium apparently has a distinct preference for invading the vascular tissues, because, even when the leaf blade is attacked, it is frequently observed that the mycelium runs mainly along a main nerve, which is then hypertrophied, and the space in the angle between two attacked nerves is often filled with numerous confluent pustules. The upper surface of the leaf, opposite the spore pustules below, is paled and somewhat reddish. Small patches of invasion on the leaf blade are usually convex above, the lower or concave surface bearing the spore beds.

The spores are brown and powdery very easily detached from their beds with only a small fragment of stalk adhering. The upper and lower cells are usually equal in size, and there is little or no constriction at the septum. They are very uniform as a rule in size and shape (Fig. 12, Pl. XII).

A fresh typical spore just moistened measured 30 μ in total length (15 μ to each cell) and 16 μ in breadth at the septum. Spores which had lain some hours in water measured on an average as follows:—whole length 30.6 μ; length of upper cell 15·6 μ; length of lower cell 14·8 μ; breadth at septum 17·6 μ. Among the spores were some fine paraphyses. There is a curious tendency in these spores to divide into more than two cells: for example I once saw a spore divided into 4 cells each 10 μ in length, the breadth of the septa being 19 μ; on two other occasions I saw a spore divided into 3 cells suggesting a comparison with *Phragmidium* spores. The epispore is beset with coarse warts or tubercles over both cells. I frequently placed these spores in water with a view to observing their germination, but on two occasions only succeeded in seeing commencing germination only in the upper cell. In one case after five days I saw a spore with a promycelium from the free end of the spore 22 μ long and 8 μ broad with colourless granular contents. In another case I saw the same after 48 hours, but in neither case did development proceed any further.*

Remarks.—I have named this species provisionally *Pucc. Geranii silvatici*, Karsten, but it is quite possibly a new species. It does not agree with the characters of *P. Geranii*, Cda.

c. Hemipuccinia.

6. Puccinia Roscoeæ, nov. sp.

on *Roscoea alpina*, Royle.

In September the leaves of this plant are often found attacked with a *Puccinia*-bearing fungus. Small pustules with a tendency to coalesce are found on the under surface of leaf blades, each surrounded by an area of paled tissue. Sometimes neighbouring areas coalesce, but as a rule each pustule remains distinct from its neighbour. Each pustule usually contains some uredopores also, which are oval, beset externally with a few spines, containing orange-yellow matter, and measuring 28 × 18 μ when moist (Fig. 1, Pl. XII). The teleutospores measure when moistened 32 μ in total length each, all being nearly equal in size (16 μ in length). The upper cell is usually somewhat broader than the lower, measuring 17 μ against 15 μ, and is thickened at its free extremity. The spore is constructed at the septum (Fig. 1, Pl. XII). These spores commence to germinate readily in water at once after ripening, but I have not observed the formation of sporidia. These are probably formed only

* As this paper was passing through the press, I observed the complete development of promycelia in the normal way. The promycelia are short and bear sporidia measuring 12 × 6 μ. Secondary sporidia are occasionally formed.

after the spores have rested for a time. I only observed the germination immediately after ripening when a promycelium was emitted from each cell, that from the upper emerging from the apex, the other from a point near the septum (Fig. 1, Pl. XII). The promycelium measures about 6 μ in diameter. I never observed the uredospores germinate.

7. Puccinia flosculosorum, (Alb. et Schw.)

on *Taraxacum officinale*, Wigg.

The leaves of this plant are frequently seen from Spring to Autumn bearing dark brown pustules mostly on their upper surfaces. Generally only the youngest entire leaves are thus attacked. Little or no discolouration of the leaf tissue is at first occasioned.

Each pustule contains numerous *Puccinia* and a few uredospores. These uredospores are chestnut-brown with resistent epispores beset with spines, and thus resemble Uromyces teleutospores rather than uredospores; but their germination reveals their true character (Fig. 3, Pl. XII). When wetted, they are round or oval, measuring 24 μ in diameter, sometimes 28 × 22 or 20 μ (Fig. 2, Pl. I). Each uredospore has two germ pores. A few pale single-celled spores may also be found (Fig. 2, Pl. XII) with vacuoles, but these are probably immature uredospores.

The teleutospores are readily detached from their beds with only a fragment of stalk adhering. They are chestnut-brown, slightly constricted at the septum, rounded at both ends and thickened at neither (Fig. 2, Pl. XII). They measure when wetted 36 μ in total length and 22 μ wide at the septum, which usually divides the spore into two equal parts. The epispore of both upper and lower cell of the spore is distinctly tuberculated. I never succeeded in getting these spores to germinate.

Remarks.—This is probably *P. flosculosorum* (Alb. et Schw.) or *P. Taraxaci*, Plow, the characters of the uredo- and teleuto-spores agreeing in every respect. But while the European species is associated with æcidial fructification, this is never found in Simla. Two varieties of the European species are described,* (*a*) *Forma crepidis* and (*b*) *Forma Hieracii* (Schum.) The former (*a*) is associated with an *æcidium*, the latter (*b*) is not. Magnus produced teleutospores of the latter (*b*) by sowing æcidiospores from *Taraxacum* on the leaves of *Hieracium*, sp. As we have no form (*b*) in Simla and no *Æcidium* on *Taraxacum*, it would appear that form (*b*) with its associated *Æcidium* is an entirely different fungus.

* Winter, loc. cit., p. 207.

8. Puccinia Galii, Pers.

on *Galium aparine*, D. C.

This fungus may be found very largely distributed in autumn, commencing about October. Small circular dark brown pustules are formed on the under surfaces of the narrow leaves with often a paled yellowish area on the corresponding opposite or upper surface. Each leaf usually contained two, or three, or even more such pustules I once counted 13 pustules on a single leaflet. These pustules contained *Puccinia* spores, with always a few uredospores, but, although I looked carefully earlier in the season, I never found simple uredo pustules.

The uredospores are oval, measuring 23 × 20 μ when well moistened, with a brown tuberculated epispore. These spores germinate readily in water, throwing out a simple germ tube after the usual manner of uredospores (Fig. 5, Pl XII). One such germ tube measured 0·315 mm. in length and 5 to 6 μ in diameter. Into this tube the protoplasm of the spores wandered, collecting in the distal end. Each spore appears to have two germ pores, but only one germ tube is emitted. A curious feature about those uredospores is the comparatively long time they retain their vitality. In a cultivation of teleutospores with material collected in October, and set in water on the 26th March following, all the uredospores present, of which there were several, germinated in 24 hours, whilst the teleutospores still remained *in statu quo*.

The teleutospores are brown bodies, not easily detached from their beds, and breaking off with a portion of stalk adhering. In each cell a distinct nuclear vesicle is seen. The spore is constricted in the middle at the septum, and the free end is considerably thickened. The septum usually divides the spore into equal halves (Fig. 4, Pl. XII). The whole length of the spore when well moistened is about 44 μ, and the breadth at the septum 14 μ. The greatest breadth of the upper cell is 21 μ, whilst that of the lower is 16 μ. The portion of stalk adherent to the detached spore is generally about 30 μ in length. The thickening of the free end of the spore is 7 to 13 μ. The above are average measurements, but the spores are not very uniform in size. These spores germinate freely in spring throwing out *promycelia* from the apex of the upper cell, or from a point a little to one side of it, and from a point near the septum of the lower cell. The *promycelia* as usual divide into 4 cells each forming a sporidium at the extremity of a sterigma. The sporidia measure about 13 × 9 μ and germinate by throwing out a narrow germ tube 2 μ in diameter.

Remarks.—I have named this *P. Galii* and not *P. Valantiæ*, Pers., as, on the whole, the characters of the teleutospore agree better with

those of the former. Moreover, the latter is a *Leptopuccinia* without uredospores. On the other hand, the uredospores of the former are somewhat larger than those I have described above, and the European species is associated with an *autœcious æcidium*, which we never find in Simla. Another difference in the Simla species is that the spore beds are always isolated, small, and circular, whilst those of *P. Galii* have a tendency to coalesce into irregular masses.

9. Puccinia Acetosæ, Schum.

on *Rumex nepalensis*, Spr.

This fungus is very common in Simla and is chiefly remarkable for an apparent lichenoid symbiosis between the mycelium and the chlorophyll-containing cells of the host, such as is described by Dr. D. D. Cunningham, F. R. S., in *Ravenelia*.*

The areas of the leaf blade invaded by the mycelium remain brilliantly green long after the rest of the leaf is yellow. The parasite is first met with in October, when the leaves may be seen to bear dark brown minute circular pustules, often with a distinctly circinate arrangement, both on the upper and lower surfaces, often in extraordinarily large numbers. At this time, if the spores be examined, they will be found to consist of round or oval single-celled bodies of a pale brown colour measuring from 24 μ in diameter to 28 × 21 μ. These spores are easily detached from their beds without any portion of the stalk adhering as a rule. They have a fairly stout epispore beset with well marked warts, and are thickened very slightly at the free end (Fig. 13, Pl. XII). The contents are sometimes finely granular throughout, but frequently several oil globules are found in the granular protoplasm. These are uredospores, and they germinate readily in water, throwing out very long simple germ tubes. I have found uredo pustules with a few teleutospores in them in March on green leaves, and the spores from them germinate very readily. I do not know whether these pustules had developed recently, or whether they had remained over from the previous autumn. My impression is that they were of quite recent formation. Later, the same pustules produce *puccinia*, which are brown, rounded, and with little or no constriction at the septum (Fig. 13, Pl. XII). These spores are very readily detached from their beds, breaking off with only a minute fragment of the stalk adhering. They have a characteristic knob-like thickening at the free end. The total length of the moistened spores varies from 40 to 32 μ, and the breadth at the septum from 18 to

* On a new Genus of the Family *Ustilagineæ*, 'Scientific Memoirs by Medical Officers of the Army of India,' Part III, p. 31.

22 μ. The average length is 35 μ, and the average breadth at the septum, which usually divides the spore into two equal parts, is 19·8 μ. I have never observed the germination of these spores.

Remarks.—These characters agree on the whole with those of *P. Acetosæ*, and I think there can be no doubt that the European and the Simla forms are identical. In the Simla species I have never observed pustules on the petiole or stalk as in the European species.

10. Puccinia helvetica, Schröter.

on *Rubia cordifolia*, Linn.

In July, soon after the rains have commenced, this plant puts out new leaves, which are early attacked by a uredo-bearing fungus, differing from most similar fungi in the uredo-pustules being brown and being intimately associated with spermogonial production. On the upper surface of the leaf, a number of pale yellow circular patches are seen, irregularly scattered about, each measuring about 3 mm. in diam. (Fig. 5, Pl. XIII.) The number of pustules on each leaf varies from one to 120, and even more. Within the paled circular area, a circle of minute brown uredo pustules are produced, which sometimes remain separate, but which sometimes coalesce laterally, and within this brown circle, in the centre of the yellow patch, is a group of spermogonia. Viewed from the lower surface (Fig. 4, Pl. XIII) of the leaf, the yellow discoloration is less marked, but the circinate arrangement of uredo pustules is even better marked than above, and, in the centre, on the lower surface also, is a smaller group of spermogonia. The circles of brown uredo pustules on the upper and lower surfaces of the leaf are exactly opposite each other.

Those brown pustules contain brown uredospores, borne singly on stalks, with a few paraphyses among them. The spores, which are oval, are readily detached, coming off without any portion of stalk adhering, although the place of union with the stalk is generally clearly recognisable on the detached spore. The spores have a well defined epispore beset with sharp spines, and, when just wetted with water, measure on an average 26·8 × 21·2 μ. The stalks measure about 50 μ in length. These uredo pustules are found also on the petioles and stalks.

In the autumn, when the persistent leaves are drying, they are covered with black teleutospore beds, mostly exhibiting the same circinate arrangement above described, but many are also isolated as shown in (Fig. 6, Pl. XIII). These teleutospore pustules are mostly on the upper surface of the leaf, but a great many are formed also on the under surface. The dried leaves remain attached to the dry stalks throughout

the winter, and, indeed, do not fall off until the rains commence, when they fall, but by this time new young leaves have already been unfolded. It would thus appear that the teleutospores germinate at the commencement of the rains, infecting the new leaves, though a few experiments I made with a view to verifying this did not succeed.* If infection of the new leaves by the teleutospores on the old ones does actually take place, we have an autœcious Uredine in which the æcidial fructification has dropped out, for I am quite certain that no æcidium is produced by this fungus. It, however, remains to be proved that the teleutospores give rise to the production of uredospores. In the meantime, the fungus must be classed with such forms as *P. suaveolens*, (Pers.), *P. Oreoslini* (Strauss), and *P. Vincæ*, D. C., among the *Hemipuccinia*, all of which produce spermogonia together with uredo- and teleuto-spores, without any æcidium.

The teleutospores are plump brown spores, constricted at the septum, with well marked apical thickening, which is rounded usually, but which is sometimes conical either in the centre or laterally. The lower cell narrows towards the stalk, which is long and adherent. The surface of the epispore is smooth (Fig. 14, Pl. XII). Each cell usually displays a clear nuclear vesicle. The freshly gathered spores, when moistened, measure from 49 to 54 μ in total length (upper cell from 25 to 30 μ, and lower 24 μ) and 13 to 15 μ at the septum. The apical thickening is 8 to 9 μ in depth.

Remarks.—I have called this *P. helvetica* with some hesitation. In the European species no mention is made of the existence of spermogonia, a prominent and invariable feature in the Simla species; but the measurements of the uredo and teleutospores correspond fairly well.

11. Puccinia Menthæ, Pers.

on *Origanum vulgare*, Linn.

While writing this list, I found, in March, this host harbouring a *Puccinia*-bearing fungus. Some plants were very extensively attacked, bearing dark brown pustules on the under surface of the blade. The pustules are small, round, and hemispherical, and do not tend to coalesce. Sometimes each leaf bears a very large number of such isolated pustules, sometimes only one. The position of these pustules is indicated on the upper surface of the leaf by dark spots surrounded by a zone of slightly paled tissue. The pustules contain both brown uredospores and teleutospores, the former the more numerous (at this season at any rate). Both spores are very easily detached from the spore bed.

* As this paper was passing through the press, I succeeded in reproducing the uredo stage with the sporidia of teleutospores gathered in the preceding autumn.

The uredospores are light brown, mostly round, some oval or pyriform, with a tuberculated or spiny epispore. They measure, when just moistened, about 25 μ in diameter. They germinate very readily in water, throwing out an ordinary germ tube, simple and unbranched. When germinating, they are seen to possess 2 to 3 germ pores.

The teleutospores fall off easily, with a short piece of stalk adhering. They are brown, rounded at both ends, little or not at all constricted at the septum, without apical thickening as a rule, and with a tuberculated or spiny epispore. When just wetted, they measure about 28 μ in total length by 20 μ at the septum. The septum divides the spore into two equal halves. These spores also germinate readily at once. The promycelium is short, and usually produces 3 to 4 sporidia on very short sterigmata. The sporidia are oval, measuring $8{\cdot}5 \times 6{\cdot}5\,\mu$ to $10 \times 8\,\mu$. They germinate readily, throwing out a fine long germ tube (Figs. 15, 16, Pl. XII).

Remarks.—I have called this *P. Menthæ*, provisionally, as the uredospores and teleutospores agree in characters with those of that species. It must be observed, however, that the æcidium is unknown here, and I have therefore placed the parasite under *Hemipuccinia*, and not under *Auteupuccinia*, as is of course done in Europe, where the æcidium also occurs on the same host. In this respect, both this Indian species and that on *Taraxacum officinale* (see above) are interesting in being unaccompanied by æcidial fructification. Biological evidence may show, later, either that the species is distinct from the European, or that the æcidial fructification on the same host in Europe is not genetically related with the uredo- and teleuto-spores.

d. Eupuccinia (heterœcious).

12. Puccinia Polliniæ, Barclay.

on *Pollinia nuda*, Trin.

This is an exceedingly abundant species, and is related to the *Æcidium* on *Strobilanthes Dalhousianus*, Clarke (*Æcidium Strobilanthis*, Barclay*). Uredopustules are situated mostly on the under surface of the leaf, and are not numerous: they are oval or shortly linear. The uredospores are pale brown, and the epispore is beset with tubercles. They measure on an average $21{\cdot}6 \times 20{\cdot}2\,\mu$.

The teleutospore beds are usually very numerous on each attacked leaf, mostly in the lower surface; they are long, linear, and black. The spores germinate readily immediately after ripening, as well as after a

* On the Life History of a new *Æcidium* on *Strobilanthes Dalhousianus*, Clarke. 'Scientific Memoirs by Medical Officers of the Army of India,' Part II, Calcutta, 1887.

winter rest. They are firmly adherent, and a portion of stalk remains on detached spores. The spores are rounded at both ends, but little constricted at the septum, and with the free end slightly thickened. The epispore is studded with fine tubercles. The spores measure 36 μ in total length, and 16 μ at the septum. The upper promycelium emerges from the apex of the spore, a little to one side, and the lower from a point near the septum. The sporidia measure from $10 \times 6\ \mu$ to $12 \times 7\ \mu$ (*see* also J. A. S. B., Vol. LVI, Pt. II, No. 3, 1887).

13. Puccinia Caricis, Schum.

on *Carex setigera*, Don.

This is a widely distributed species and stands in genetic relationship with *Æcidium Urticæ*, Schum, var. *Himalayense*, Barclay.*

Uredopustules are not very numerous, and are found on the upper surfaces of the leaves: they are inconspicuous, small, brown, and linear or oblong. The spores are elliptical or pyriform, and are beset with prominent tubercles. They are pale yellow, and measure on an average from $19{\cdot}8 \times 13{\cdot}5\ \mu$ to $19{\cdot}2 \times 12{\cdot}8\ \mu$.

The teleutospore pustules are minute, circular, and black, mostly on the upper surfaces of the leaves. The spores are dark brown, firmly adherent, constricted at the septum, thickened at the free end, and usually narrowing towards the stalk. They germinate readily immediately after ripening as well as after a winter rest. They measure on an average 56 μ in total length and 15 μ at the septum. The promycelium of the upper cell emerges from the apex, and that of the lower, from a point near the septum. Four sporidia are formed usually on each promycelium, measuring $12 \times 8\ \mu$.

e. Epuccinia (antœcious.)

14. Puccinia Violæ, Schum.

on *Viola serpens*, Wall.

15. Puccinia Fragariæ, Barclay.

on *Fragaria vesca*, Linn.

For descriptions of these two *Puccinia*, *see* J. A. S. B., Vol. LVI, Part II, 1887.

16. Puccinia Pimpinellæ, Strauss.

on *Pimpinella diversifolia*, D. C.

I have described the characters of this fungus in the Journal of

* 'Scientific Memoirs by Medical Officers of the Army of India,' Part II, 1887.

this Society above quoted. I then noted that the teleutospores are formed in autumn, and that I had not observed their germination. Early this Spring (middle of February), however, I observed a few young *seedlings* with teleutospore pustules on the young green leaves of the same characters as those I found in autumn, and these germinated early in March in water. The promycelium of the upper cell emerges from the upper half of the upper cell, but not from its apex (*see* Fig. 12, Pl. XIII), whilst that from the lower cell emerges from a point nearer the stalk than the septum, and takes a course in a direction opposite to that of the upper promycelium. The sporidia are long narrow bodies, about 26 μ to 18 μ in length and 8 μ in width, on short pointed sterigmata, and the promycelial tube opposite a sterigma is about 10 μ in diameter. The sporidia frequently germinate while still attached to the promycelium.

Early in March, I found similar young seedlings already attacked by an *Æcidium*, but, although I made several attempts to reproduce the *æcidium* with these freshly gathered and germinable teleutospores, I did not succeed. I am therefore forced to believe that the teleutospores are not genetically related with the *æcidium*-bearing fungus on the same host. The matter requires further investigation.

LIST II.

17. Puccinia Arundinellæ, nov. sp.

on *Arundinella setosa*, Trin., and *A. Wallichii*, Nees.

This fungus is not uncommon. The teleutospore beds are oval or slightly linear on the under surface of the blade. The uredo pustules are peculiarly brilliant brick red, and are formed in July and August. The teleutospores are brown bodies slightly constricted at the septum, somewhat thickened at the free end, and breaking off usually with a long portion of stalk adhering (Figs. 7, 8, Pl. XIV). In each cell a nuclear vesicle is often present. The whole length of the spore when moistened is about 46 μ, of which 24 μ belong to the upper cell, and 22 μ to the lower. The breadth at the septum is about 20 μ. After a winter's rest, these spores readily germinate in water, each cell throwing out a characteristic promycelium. That from the upper cell usually emerges first from the apex of the spore, while that from the lower cell issues from a point near the septum (Fig. 7, Pl. XIV). Each promycelium forms four sporidia on as many sterigmata, and the sporidia, which are oval or kidney-shaped, measure on an average 10 $\times$ 7 μ, varying from 9 $\times$ 5 μ to 11 $\times$ 7 μ. The portions of stalk adhering to the spore measure 110 to 120 μ in length.

This fungus on *A. Wallichii* is not common. It forms linear black pustules on the lower surface of the leaf. I have not found uredospores on this host. The teleutospores are brown, rounded at both ends, equally divided into two by the septum, not constricted at the septum and thickened at the free end. Freshly gathered spores moistened measure on an average 40 μ in total length and 18 μ at the septum. The thickening at the free end measures about 8 μ in depth. The free end is usually rounded, but sometimes more or less pointed. The spores break off from their beds with a long piece of stalk adhering (Fig. 11, Pl. XIII).

Remarks.—I have grouped these two fungi together, as the teleutospores resemble one another closely; but subsequent observation may prove them to be distinct. It is I believe a new species.

18. Puccinia Andropogi, Schw.

on *Andropogon tristis*, Nees.

This is not a common fungus, and I have only found teleutospores. Pustules of these spores are formed on the lower surface of the leaf; they are linear or oval, tending to coalesce, and very numerous on each attacked leaf. The spores are firmly adherent, in long stalks, brown, rounded usually at both ends, and thickened at the free end. The spore is slightly constricted at the septum (Fig. 13, Pl. XIV). Freshly gathered spores, when moistened, measure from 34 to 41 μ in total length; the upper cell varies from 17 to 21 μ and the lower from 16—20 μ. The width at the septum is 16 to 22 μ, and the apical thickening about 8 μ in depth.

Remarks.—Two species of *Puccinia* on species of *Andropogon* are described in America,* one referred to *P. Phragmitis* (Schum) and the other to *P. Andropogi*, Schw. If the Indian species is identical with either, it is more probably with the latter, and I have therefore named it accordingly for the present.

19. Puccinia Anthistiriæ, nov. sp.

on *Anthistiria anathera*, Nees.†

The leaves, haulms, and glumes of this grass are often attacked by a fungus, bearing large conspicuous beds of sooty black teleutospores, sometimes so confluent, and so largely involving the surface area of the part attacked as to suggest the idea that it is one of the *Ustilagineæ*. Small linear or oval beds are also met with, and indeed the large beds are the result of the coalescence of these primarily small beds. The

* Bulletin of the Illinois State Laboratory of Natural History, vol. ii, art. iii, Parasitic Fungi of Illinois, pt. i, by T. J. Burrill, 1885.

† I am not quite certain that this host has been correctly determined: it may prove to be a species of *Bromus*.

spores are very firmly adherent, and, when scraped off, become detached with a long piece of stalk attached (Fig. 6, Pl. XIV). The spores are spindle-shaped, pale brown when seen by transmitted light, well constricted at the septum, and with a distinct apical thickening. Each cell of the spore usually displays a clearly defined nuclear vesicle. The fresh spore, when moistened, measures on an average 45·6 μ; the upper cell is usually a little longer than the lower, which contracts towards the stalk. The width at the septum is about 13 μ, and the thickening at the free end is 6 to 7 μ. Towards the end of March these spores germinate in the usual way. The sporidia are oval, and measure 8 × 6 μ. I have not met with any uredospores on this grass.

Remarks.—This is probably a new species.

20. Puccinia Chrysopogi, nov. sp.

on *Chrysopogon gryllus*, Linn.

This is a very abundantly distributed parasite, forming well raised plump, oval, or broadly linear dark brown pustules: they germinate very readily in spring in water. After 24 hours in a water cultivation they were observed to have thrown out long promycelia, into the distal ends of which the orange-yellow contents of the spore had wandered. The end of the promycelium divides into four cells, each of which produces a sporidium on unusually long sterigmata. The sporidium (14 × 12 μ), which is oval, often germinates while still attached to the sterigma, forming a secondary sporidium. The germ tube of the primary and secondary sporidium is often slightly spiral (Fig. 10, Pl. XIV). The promycelium of the upper cell emerges from a point near the apex of the cell, and that from the lower from a point near the septum (Fig. 9, Pl. XIV). The promycelia were often observed to acquire unusual forms, such for example as is represented in the figure, where the promycelium of the upper cell has divided into three cells, two of which have thrown out remarkably long and stout sterigmata, which, however, remained sterile. The cultivation was in water. The spores are slightly constricted at the septum, and the apex is little if at all thickened. On an average the moistened spore measures 43 μ in total length, and 24 μ at the septum. In each cell a well defined nuclear vesicle is usually seen. The detached spore has usually a very small portion of the stalk adhering to it. The spores are firmly set in their beds.

The teleutospores are preceded by uredospores, which are round or oval orange-red bodies. *Young* teleutospores are often seen in fully developed uredopustules. The uredospores measure, when moistened, from 23 μ in diameter to 33 × 26 μ, the average being 28·7 × 26·5 μ.

Remarks.—This is probably a new species.

21. Puccinia coronata, Corda.

A. on *Brachypodium sylvaticum*, Beauv.

This fungus is not very common, and is usually found in localities where an Æcidium on *Rhamnus dahuricus*, Pall., occurs. I have already expressed my belief that it is related to this æcidium,* although I have not been able to prove it by experiment. The teleutospore beds form very minute black points on the upper surfaces of the blade, sometimes arranged linearly; but they never coalesce to form linear beds. The uredo pustules are much larger, orange-yellow, and also on the upper surface of the leaf.

The uredospores are pale saffron-yellow bodies, with a finely punctated epispore, measuring when just moistened 20 to 24 μ in diameter (Fig. 3, Pl. XIII). They germinate in the usual way by throwing out a single germ tube. There are three or four germ pores, but only one germ tube is emitted (Fig. 5, Pl. XIV).

The teleutospores are brown with the characteristic crown of generally regularly arranged processes (Fig. 3, Pl. XIII and Figs. 1, 4, Pl. XIV). They are borne on short stalks, and each cell usually displays a well defined nuclear vesicle. The total length of the just moistened spores is 38 to 44 μ, the upper cell measuring from 18 to 22 μ, and the lower, 19 to 26 μ; the width at the septum is 10 to 11 μ. The spore narrows gradually towards the stalk, and is scarcely at all constricted at the septum. They do not germinate until after a winter's rest. In the spring they germinate freely; the promycelium from the upper cell emerging from a point immediately under the crown (Fig. 1, Pl. XIV), and that from the lower cell, from near the septum. Four sporidia are usually formed at the ends of short pointed sterigmata (Fig. 1, Pl. XIV). The sporidia are oval bodies measuring on an average 11 × 6·8 μ, varying from 10 × 6 μ to 13 × 9 μ. They germinate readily (Fig. 2, Pl. XIV). The promycelium at the base measures 6 to 7 μ, but opposite the sterigmata only 4 to 5 μ.

B. on *Chrysopogon cœruleus*, Nees.

This is an uncommon parasite resembling the above in the teleutospores being coronated, but I am inclined to think it is a distinct species, because the spores themselves have a different form, and the crown of processes is usually very irregular, contrasting with the usually regular crown of the fungus above described. Other noteworthy differences are the following:—The teleutospore pustules are *linear*, and on the lower surface of the leaf. Uredopustules are placed also on the under

* J. A. S. B. vol. lvi, pt. ii, no. 3, 1887.

surface, and these are produced throughout the winter, as I have found them late in autumn, and very early in February, whilst I have never found the uredo pustules of the foregoing fungus after summer.

The uredospores are circular, oval or pyriform, and, when just moistened, vary from 17 μ in diameter to 26 × 21 μ. Their contents are pale orange-yellow, but their coloured matter is characteristically confined to the centre of the spore, leaving a colourless periphery about 2 μ in depth; the epispore is smooth (Fig. 3, *b*, Pl. XIV).

The teleutospores are adherent, falling off with a small portion of stalk attached. The crown processes, as already noted, are remarkably irregular, and the individual processes are often very long (Figs. 9, *a*, *b*, *c*, Pl. XIII and Fig. 3, *a*, *c*, Pl. XIV). The freshly gathered spores, when just moistened, have the following dimensions:—whole length 43 to 55 μ, the mean being 49 to 50 μ; the upper cell on an average 25 μ long, and the lower 24 μ; the breadth at the septum 8 to 12 or 14 μ. These spores, I found, germinated very freely in water so early as the 15th Feburary, when most other teleutospores were still incapable of doing so, and when the spores of the foregoing fungus only commenced to germinate, without proceeding to the formation of sporidia. The lower cell usually germinated first. Four sporidia are usually formed on each promycelium; these are oval and measure about 9 × 7 μ.

C. on *Agrostis Hookeriana*, Manw.

A third form occurs on *Agrostis Hookeriana* with characters more nearly resembling form B. than form A. The teleutospores are almost identical in form and measure 44 to 50 μ in total length, and 8 to 10 at the septum (Fig. 12, Pl. XIV). In the absence of biological data, however, it is impossible to say definitely whether all these forms belong to one species, but until these are forthcoming they may conveniently be grouped together. I have not seen any uredo form on *Agrostis*.

22. Puccinia Graminis, Pers.

on *Festuca gigantea*, Vill.

In certain localities this *Puccinia* is very abundant. The teleutospore beds are very narrow and long, forming black lines on the upper surface of the blade. These pustules, when not very numerous on a single leaf, are generally found on the distal half, but otherwise the whole of the upper surface is uniformly involved.

Saffron-yellow uredopustules, mostly on the lower surface, precede the formation of teleutospores. The uredospores are round or oval, and orange-yellow, with an epispore beset with spines. The orange-yellow contents are often aggregated in the centre, leaving the periphery filled

with granular uncoloured matter. The fresh spores measure on an average 30·6 × 27·6 μ varying from 28 μ in diameter to 32 × 28 μ.

The teleutospores are long, narrow, and characteristically square shaped (Fig. 10, Pl. XIII), the free end being squarely thickened. The total length of the fresh spore, when moistened, varies between 34 and 41 μ; the upper cell measuring 16 to 20 μ in length, and the lower, 17 to 21 μ. At the septum the breadth of the spore is 8 to 10 μ.

Remarks.—I have named this *P. graminis*, as I find Plowright* mentions the same host as bearing this species, although the measurements of my teleutospores are smaller than those given by him. The Berberry æcidium, as I have already noted, is very common in Simla.

23. Puccinia Caricis filicinæ, nov. sp.

on *Carex filicina*, Nees.

This is not a common fungus, and is usually very inconspicuous, bearing very minute circular teleutospore beds (resembling in this respect the same beds of *P. caricis* on *Carex setigera*, which, though small, are yet considerably larger than those on *Carex filicina*). Only a few minute spore beds are usually formed on each leaf, and always on the lower surface. Spore beds are also occasionally formed on the sheath. I have not seen any uredo pustules on this plant.

The teleutospores are borne on long stalks, and are firmly adherent. They are brown, much constricted at the septum, and thickened at the free ends (Fig. 1, Pl. XIII). When freshly gathered and moistened, a representative spore measured 44 μ in total length, of which 24 μ belonged to the upper cell, and 20 μ to the lower. The breadth at the septum was 12 μ, and the apical thickening was 8 μ in depth. These spores germinate freely in spring in water, after a winter's rest. The promycelium of the upper cell emerges from the apex, through a pore which is clearly visible before germination, and that of the lower, from a point near the septum. Each promycelium usually produces four sporidia in the usual way (Fig. 2, Pl. XIII). The sporidia are oval, somewhat more pointed at the attached end than at the free end, and measure 9 × 6 μ to 12 × 6 μ. These sporidia usually emit a germ tube from the side, and not from either end.

Remarks.—I frequently placed these teleutospores on leaves of *Urtica parviflora*, Roxb., but the well known *Æcidium Urticæ*, Schum, was never produced. It is therefore certainly distinct from *P. Caricis*, Schum. The characters of *P. limosæ*, Magnus, and *P. silvatica*, Schröter, do not agree with those above described.

The former is connected with an *Æcidium* on *Lysimachia*, and we

* British *Uredineæ* and *Ustilagineæ*, Plowright, Keegan, Paul, Trench & Co., 1889.

have no corresponding Æcidium in Simla, and the latter, with an Æcidium on *Taraxacum*, and we have similarly no corresponding Æcidium here. The only Æcidium on any member of the *Compositæ* that I have met with is that on *Myriactis nepalensis*, Less., and I have never found it actually in Simla.* I must therefore regard this *Puccinia* as a new species, at any rate for the present.

DESCRIPTION OF THE PLATES.

Plate XII.

Fig. 1. *Puccinia Roscoeæ*, uredospore and two teleutospores; one with two promycelia. 2. *P. flosculosorum*, two uredospores and one teleutospore. 3. *P. flosculosorum*, uredospore germinating. 4. *P. Galii*, teleutospore. 5. *P. Galii*, uredospore germinating. 6. *P. Rosæ*, teleutospore showing commencing germination in upper cell, × 400. 7. *P. Rosæ*, teleutospore showing promycelium of upper cell with two sporidia, × 400. 8. *P. Rosæ*, sporidium germinating, × 250. 9. *P. Urticæ*, teleutospores, with branched promycelium from lower cell. 10. *P. Geranii silvatici*, natural appearance of attacked leaf, natural size. 11. *P. Geranii silvatici*, showing hypertrophied node caused by mycelium, natural size. 12. *P. Geranii silvatici*, teleutospore, after lying 24 hours in water, × 400. 13. *P. Acetosæ*, two uredospores and one teleutospore. 14. *P. helvetica*, teleutospore. 15. *P. Menthæ*, germinating teleutospore with sporidia. 16. *P. Menthæ*, germinating sporidium.

Plate XIII.

Fig. 1. *Puccinia Caricis filicinæ*, germinating teleutospore. 2. *P. Caricis filicinæ*, end of promycelium showing sporidial formation. 3. *P. coronata*, from *Brachypodium silvaticum*, showing representative teleutospore and uredospore. 4. *P. helvetica*, lower surface of leaf in uredo stage. 5. *P. helvetica*, upper surface of leaf in uredo stage. 6. *P. helvetica*, upper surface of leaf in teleutospore stage. 7. *P. Saxifragæ ciliatæ*, natural appearance. 8,*a*. & 8,*b*. *P. Saxifragæ ciliatæ*, teleutospore. 9. *P. coronata*, from *Chrysopogon cœruleus*: *a*., showing an upper cell with promycelium and sterigmata, from which the sporidia have fallen: *b*., germinating sporidium: *c*., another teleutospore. 10. *P. graminis*, teleutospore. 11. *P. Arundinellæ* on *A. Wallichii*, teleutospore. 12. *P. Pimpinellæ*, germinating teleutospore with sprouting sporidia still attached.

Plate XIV.

Fig. 1. *Puccinia coronata*, from *Brachypodium sylvaticum*, teleutospore with promycelium. 2. *P. coronata*, germinating sporidia. 3. *P. coronata*, from *Chrysopogon cœruleus*; *a*. and *c*., forms frequently met with on this host: *b*., two uredospores are also shown. 4. *P. coronata*, typical teleutospore from *Brachypodium sylvaticum*. 5. *P. coronata*, germinating uredospore (*Brachypodium sylvaticum*) 6. *P. Anthistiriæ*, teleutospore. 7. *P. Arundinellæ*, on *A. setosa*, germinating teleutospore. 8. *P. Arundinellæ*, typical teleutospore. 9. *P. Chrysopogi*, germinating teleutospore, with abnormally long sterile sterigmata from upper promycelium; *b*., germinating sporidium. 10. *P. Chrysopogi*, germinating sporidium. 11. *P. Circææ*, teleutospore. 12. *P coronata*, from *Agrostis Hookeriana*. 13. *P. Andropogi*, teleutospore. 14. *P. Fragariæ*, teleutospore.

N. B.—*Unless otherwise specified all figures are* × 350.

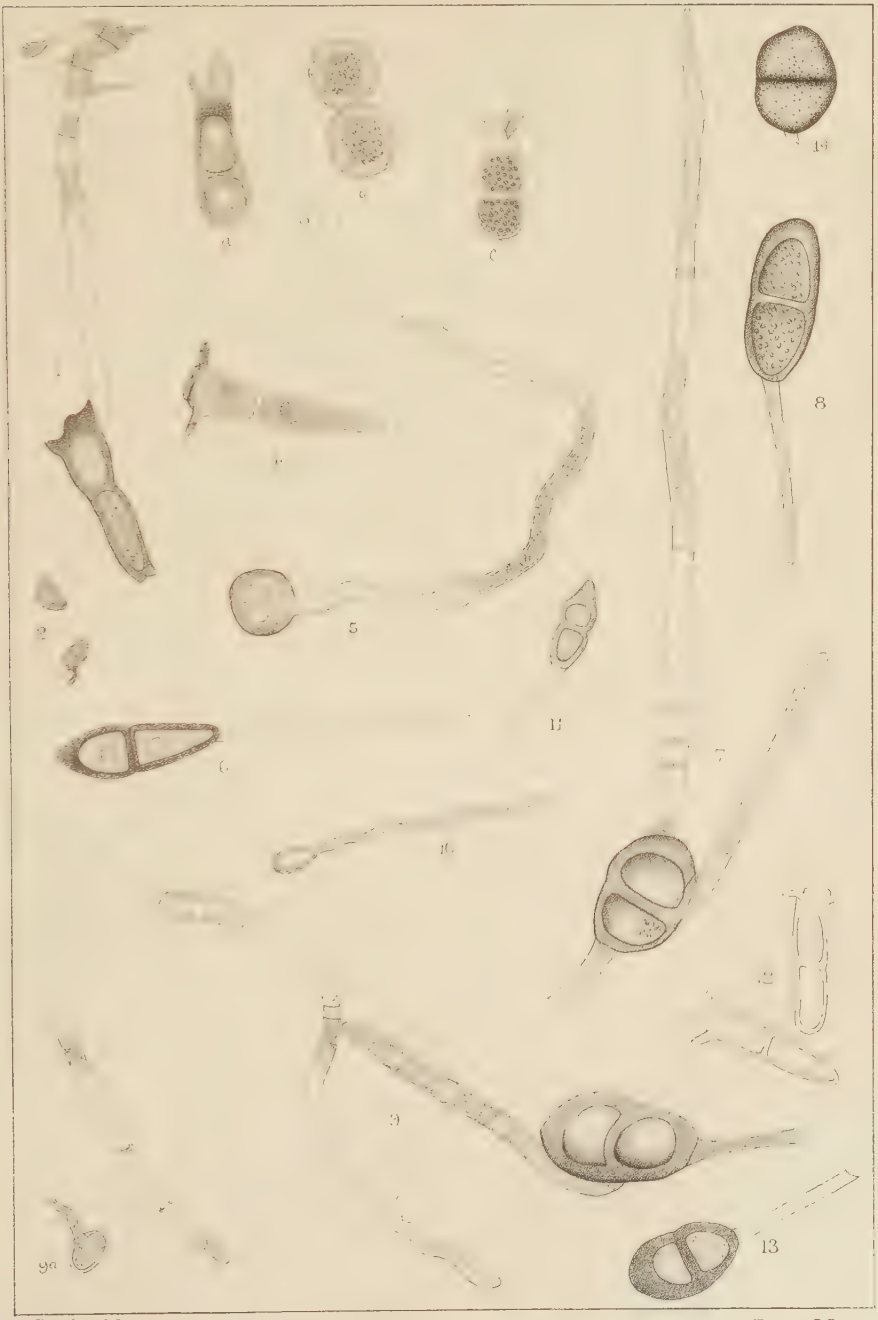
* J. A. S. B. vol. lvi, pt. ii, no. 3, 1887.

A.Barclay del.
Parker & Coward lith.

West, Newman & Co.

A. Barclay del.
Parker & Coward lith.

West, Newman & Co.



A. Barclay del.
Parker & Coward lith.

West, Newman & Co. imp.

A

DESCRIPTIVE LIST

OF THE

UREDINEÆ

OCCURRING IN THE

NEIGHBOURHOOD OF SIMLA (WESTERN HIMALAYAS).

PART III.

BY

A. BARCLAY, M. B.

BENGAL MEDICAL SERVICE.

[*Reprinted from the Journal of the Asiatic Society of Bengal, Vol. LIX, Part II, No.* 2, 1890.]

CALCUTTA:

PRINTED AT THE BAPTIST MISSION PRESS.

1890.

A Descriptive List of the Uredineæ *occurring in the Neighbourhood of Simla (Western Himalayas).* Pt. III.—*By* A. Barclay, M. B., *Bengal Medical Service.*

[Received January 27th ;—Read February 5th, 1890.]

(With Plates III.—VI.)

In this third instalment of a descriptive list of the *Uredineæ* of Simla (in continuation of the second part in this Journal, Vol. LVIII, Pt. II, 1889), I complete a description of all the species known to me up to the present time. The present part includes descriptions of 6 species of *Uromyces*, 4 of *Phragmidium*, 3 of *Melampsora*, 3 of *Coleosporium*, 1 of *Gymnosporangium*, 2 of *Chrysomyxa*, 2 of *Cæoma*, and 6 of isolated *Uredo* forms. I have also added descriptions of four *Aecidial* forms, which should have been included in Part I of this List, and seven species of *Puccinia*, which should have found a place in Part II.

I must here express my obligations to Dr. George Watt, C. I. E., for his kind and ever ready help in determining the species of many hosts.

UROMYCES, Link.

There are remarkably few of these in this region, only six species so far as I am at present aware, and all but one on the higher phaner-

ogamous plants, the exceptional one being on a grass. The most remarkable of these is *U. Cunninghamianus*, presenting extremely anomalous characters. Another interesting species is that on *Strobilanthes*, as this host also bears an *Aecidium* which is, however, in no way related to the teleutosporic fungus.

a. HEMIUROMYCES, Schröter.

1. Uromyces Vossiæ, nov. sp.

On *Vossia speciosa*, Benth.

This grass is sometimes largely attacked by a species of *Uromyces*. In August the leaves may be seen in commencing attack with the formation of brown uredo pustules on the under leaf surface. These pustules are small, oval or linear, and isolated.

The *uredospores* are brownish, with sometimes a tinge of orange red, very deciduous, falling off without any portion of stalk adhering. The cell wall is uniform in thickness, and presents three or four pores, easily seen by treatment with sulphuric acid. They measure on an average $24 \times 19{\cdot}2\mu$, varying from 25×22 to $23 \times 17\mu$. The epispore is finely warty. They germinate in water in the usual way, throwing out a simple germ tube (fig. 1, Pl. I.)

Late in the year *teleutospore* pustules are formed. These are well raised oval or linear dark brown sori, also hypophyllous. The spores are very readily detached, coming off with a small portion of stalk adhering. They do not germinate on maturing, but only after a period of rest. These are thicker walled than the uredospores, and are especially thickened at the apex. They measure from 24×21 to $29 \times 22\mu$, when fresh and examined in water. In spring they germinate very readily in water (fig. 2, Pl. I.)

b. UROMYCOPSIS, Schröter.

2. Uromyces Cunninghamianus, Barclay.

On *Jasminum grandiflorum*, L.

For a complete description of this parasite I must refer the reader to a paper on its life history read at the Linnean Society on the 18th December, 1889. The diagnostic characters of the species are as follows:

Towards the end of August the leaves and smaller stems of the host are largely attacked in the aecidial stage, and these are then much hypertrophied. The peridia burst in a stellate fashion, allowing the orange red aecidiospores to fall out. When these spores have been shed, teleutospores are formed within the old peridia. These teleutospores are

adherent, and remain in a quiescent state until the following year, when they germinate and reproduce aecidia on the newly developed leaves. Experimental evidence, which will be found detailed in the above-mentioned paper, fully confirmed the autœcious nature of the fungus.

The *aecidiospores* are round or oval pale yellow bodies, and measure on an average 16μ in diam. They are tuberculated on the outer surface. Their mode of germination is quite peculiar. A germ tube is emitted, about 35μ in length, which then divides into two by a transverse septum, and each part forms a long narrow sterigma, which, however, forms no sporidium, but directly penetrates the host to form another mycelium, bearing aecidiospores at first (but no spermogonia) and teleutospores later.

The *peridium* is formed of a single layer of cells about $26 \times 19\mu$ in size.

The *spermogonia* accompany the first crop of aecidia: they are not numerous, and measure about 145μ in depth and width. They have a tuft of protruding paraphyses.

The *teleutospores* are brown single-celled bodies, thickened at the free end, firmly adherent to their beds, becoming detached with a portion of stalk adhering. They measure $36 \times 20\mu$ on an average. They germinate after a winter's rest in the usual way, each promycelium forming three sporidia as a rule, but sometimes four.

The *sporidium* is oval, and measures $12 \times 8\mu$ to $14 \times 10\mu$. Secondary sporidia are abundantly formed, often before the primary one has become detached.

3. Uromyces Valerianæ, Schum.

On *Valeriana Wallichii*, D. C.

For a description of this species see the Journal of this Society, Vol. LVI, Part II, No. 3, 1887, page 352.

Dr. P. Dietel (Leipzig) to whom I sent specimens of this fungus thinks it is a new species.

c. LEPTUROMYCES, Schröter.

4. Uromyces Solidaginis, Niessl.

On *Solidago Virgaurea*, L.

This host may be found in some localities largely attacked in August and September. Attention is drawn to the fungus by the circular discoloured patches produced, mostly on the radical leaves, but sometimes also on higher leaves. An attacked plant, however, does not usually form a flowering stalk. These discoloured patches (pale yellow)

when first coming to notice are about 5 m.m. in diameter, and then bear but a few spore pustules on the lower surface; but as they grow older they enlarge, become paler, and therefore more conspicuous, bear very numerous minute pustules, still mostly on the lower surface, but a few isolated ones on the upper surface also. An old patch may attain a diameter of 1 c.m. A single leaf may bear from 1 to 30 patches and even more. The spore pustules are minute brown sori, with the spores fairly adherent. If these spores be examined they are found to be teleutospores; there are no uredospores. A careful search over both the upper and lower surfaces of patches disclosed no spermogonia, even on the youngest.

Each spore is pale brown, with a small portion of stalk adhering, much thickened at the apex, and with a clearly defined nucleolar space. Through the apical thickening a germ pore may be seen. The free end of the spore is usually rounded, but is sometimes conical, and may even be pointed. The surface of the spore is smooth. The fresh spores examined in water measure 27 to 30 by 17μ, the apical thickening being 10μ. These spores germinate at once, if placed in water in a watch glass, in the usual way, producing four sporidia on long narrow sterigmata. The sporidia are round to oval, measuring from 10μ in diameter to 12 $\times$ 10μ. These also germinate readily. If the spores are placed in a hanging drop of water, with very little air, the peculiar germination described by Kienitz-Gerloff as occurring in *Gymnosporangium* spores takes place. That is to say, the end of the promycelium breaks up into three or four cells, which become detached, and which further germinate by throwing out a germ tube. I have already described this in a paper on the life history of *Cæoma Smilacis*, the teleutospores of which exhibit the same phenomenon.* These detached cells, which apparently act as sporidia, measure from 8 $\times$ 8 to 18 $\times$ 9μ, or on an average of several measurements 14·0 $\times$ 8·1μ.

d. MICRUROMYCES, Schröter.

5. Uromyces Strobilanthis, nov. sp.

On *Strobilanthes Dalhousianus*, Clarke.

In autumn the leaves of this host bear numerous pustules on the lower surface. Whilst it is common in some years it is rare in others. I could not, for instance, find any in 1889. The spores are very firmly adherent to their beds and when scraped off retain a portion of stalk. They are more or less elongated bodies, reddish brown by transmitted

* Scientific Memoirs by Medical officers of the Army of India, Part IV, 1889.

light, with the free end considerably thickened. When well moistened the spores measure from 26 × 16 to 34 × 14μ, or on an average of several measurements 30·4 × 14·6μ. The length of the stalk adherent is usually about 40μ. They germinate only after a period of winter rest; at least they do not germinate in autumn; but I have not observed their germination in spring.

This teleutospore has no genetic relationship with the *Aecidium* borne by the same host.*

6. Uromyces McIntirianus, nov. sp.

On *Hemigraphis latebrosa*, Nees.

This fungus was collected by Mr. A. L. McIntire, of the Forest Department, in the Simla region; but I have not myself found it. The pustules are circular, minute, coalescing, and mostly hypophyllous. The spores are brown, coming off with a long piece of stalk attached. They are oval, contracting slightly towards the stalk, slightly thickened at the apex which is rounded, and quite smooth on the surface. Among them are a few two-celled spores (*Puccinia*) and some fewer single celled but much larger spores, possibly though not probably of the nature of uredo-spores. The teleutospores vary considerably in size, 33 — 24 × 26 — 18μ, when just moistened. The few two celled spores measured 38 — 32 × 24 — 16μ. These spores are also brown, rounded at both ends, smooth, and with little or no constriction at the septum. The large single-celled spores measured 36 — 34 × 27 — 22μ. None of these spores germinated when placed in water; but they had been preserved some months in botanical drying paper.

Remarks.—As far as I am able to determine this is a new species and I have named it after the collector.

PHRAGMIDIUM, Link.

a. EUPHRAGMIDIUM, Schröter.

1. Phragmidium subcorticium, Schrank.

On *Rosa moschata*, Mill.

I found this host attacked by a species of *Phragmidium* early in September. The leaves bore at this time both yellow uredo- and black teleutospore pustules, the latter readily distinguishable from the species on *Rubus* by their smaller size, and by their irregular and general distribution over the lower leaf surface, instead of being in special cir-

* Scientific Memoirs by Medical officers of the Army of India, Part II, 1886.

cular patches on the leaves. On examining the yellow pustules they were found to contain numerous uredospores, with some immature looking yellow teleutospores, while the black pustules contained mostly dark brown teleutospores. These spores were put at once into water, and while the uredospores germinated in the usual way no teleutospore did so.

The *uredospores* are angular orange red bodies, with an epispore beset with numerous warts (almost spines) and punctured by 7 to 9 germ pores. They measure about 26 to 30μ in diameter. Only one germ tube is emitted by each spore.

The *teleutospores* are readily distinguished from those on *Rubus* by their pointed or mucronate ends. In young pustules some teleutospores are orange yellow, though most are dark brown. They are also more divided, each containing usually 7 or 8 cells, but sometimes even ten. They measure about 100 $\times$ 33μ (an unusually long spore with ten compartments measured 126 $\times$ 33μ). The spores are covered with coarse warts. Another peculiarity consists in a very well marked bulging in the stalks with a cavity containing yellowish granular matter (fig. 3, Pl. I). These spores germinate only after a period of winter rest. In April I obtained sporidial formation in spores I had kept since the preceding autumn. The sporidia are spherical, bright orange red, and 9·5 to 125μ in diameter.

The *aecidial stage* consists in the formation of very bright orange red beds, sometimes of very extensive area. These beds are formed on the leaves and on the smaller stems, and the mycelium bearing them always gives rise to hypertrophy, sometimes very excessive, on the stems. In the latter situation the hypertrophy is due to an excessive enlargement of the parenchyma cells between the hypoderma and the central vascular bundles. This stage is met with throughout the summer months. The aecidiospores are given off in long chains, but there is no peridium of any kind. The margin of beds is, however, fringed with club-shaped paraphyses. In this stage spermogonia are numerous. They are superficial, and frequently coalescing groups of them may be found on the upper leaf surface opposite a bed of spores below. The aecidiospores are pale orange red or yellow oval bodies, measuring on an average 20 $\times$ 17μ. The epispore is thick and beset externally with tubercles.

A bush in my garden is frequently attacked with this aecidium-bearing fungus, but curiously enough it never bears teleuto- or uredospores.

Remarks.—This is probably *Phragmidium subcorticium*, but the hyaline point at the free end of the teleutospores is not nearly so long as is given by Schröter and Plowright in their works. I would also

draw attention to the resting property of the teleutospores which is in strong contrast with the immediate germinability of the next species.

b. HEMIPHRAGMIDIUM, Schröter.

2. Phragmidium Rubi, Pers. ?

On *Rubus lasiocarpus*, Smith.

A *Phragmidium* on this host is fairly common. On the 21st February I collected some leaves bearing both yellow uredo-like pustules and black teleutospore pustules on separate green leaves. Both kinds of pustules are hypophyllous, in scattered circular pustules, indicated above by a brownish red discoloration of the leaf, especially marked in the case of teleutospore formation. I put some spores from each kind of pustule into growing cells on the following day; but whilst none of the teleutospores from the black pustules germinated, several of those contained in the yellow pustules did so freely, forming ordinary promycelia, dividing into four parts, each bearing a sporidium at the end of a pointed sterigma (fig. 5, Pl. I). The sporidia are round orange yellow bodies, 8 to 10μ in diameter, the diameter of the promycelial tube being 8μ. These latter teleutospores were among numerous uredospores, and were orange red in colour as contrasted with the deep brown of the former teleutospores, which would not at this time germinate. The orange yellow teleutospores were evidently just formed, and, indeed, but for their ready germinability, would be described as immature spores, the more so as they contain fewer cells than the brown spores, namely, 3 to 5 cells against 5 to 7 in the brown spores. Curiously enough the uredospores, which were in the majority in such pustules did not germinate in the cultivations in which the young teleutospores did.

The *uredospores* are round pale orange yellow bodies, with numerous club-shaped paraphyses among them. They are tuberculated on the surface, and measure about 21μ, in diameter. I never succeeded in observing their germination (fig. 6, Pl. I).

Later in the year, from July to December, fresh crops of black teleutospore pustules are produced, without any uredospores. Some of these later teleutospores, which are dark brown and many-celled (on an average six-celled), I put into water on the 10th September, and now they germinated very freely, producing immense numbers of sporidia (four to each promycelium), round or pyriform in shape, orange yellow in colour, and 10 to 12μ in diameter. These brown teleutospores measure on an average 100·8 $\times$ 37μ; but of course they vary consider-

ably, especially in length. The free end of the spore is rounded, with occasionally a minute knob. The surface of the spore is beset with tubercles (fig. 4, Pl. I).

I have never seen any aecidial form of this species.

I may add that I collected some of these teleutospores from green leaves in the middle of December, and placing them in water found that they germinated very freely, even so late in the year as that.

Dr. P. Dietel is inclined to think this is a new species as it differs from *Phr. Rubi* in having thick stalks and in frequently wanting an apical cone. He thinks it comes near the Australian *Phr. Barnardi*, Plow et Winter though the latter has lighter coloured spores and forms small punctiform pustules.

c. PHRAGMIDIOPSIS, Schröter.

3. Phragmidium quinqueloculare, nov. sp.

On *Rubus biflorus*, Ham.

In April, the stems bear orange yellow pustules, the leaves very rarely. These are probably aecidia. The spores are brilliantly orange red, bluntly angular with slight thickenings at the angles, and densely beset with warts. The fresh spores measure 24 — 20μ. in diameter. The margins of the pustules are surrounded by club-shaped paraphyses. On applying sulphuric acid (with a view to determining the existence of germ pores, in which I was unsuccessful) the spores first turn deep blue and then later pale blue. The spores germinate readily in water throwing out exceedingly long slender unbranched tubes.

On old dead leaves I found numerous minute, circular, discrete, black teleutosporic pustules, very unlike those of *Phr. Rubi* (above described) to the naked eye. The teleutospores are mostly brown, but some are orange red, and are very regularly divided into 4 to 5 cells, each well rounded, with a minute, colourless rostrum at the free end. The stalk is slightly bulged, and contains a cavity. They measure 80 — 64 × 22 — 20μ. The length of each cell is about 12 — 13μ. I could not determine the number of germ pores to each cell.

After a winter rest the teleutospores germinate freely. The procelia before forming sporidia are filled with orange red matter. The sporidia are spherical and orange red, measuring 12μ in diameter, and are borne on fairly long narrow and pointed sterigmata.

Remarks.—I do not think this fungus is identical with *Phr. Rubi* Pers, *Phr. violaceum* or *Phr. Rubi-Idaei*, Pers. I have regarded it as a new species provisionally ; but it is difficult to be certain about this.

d. PHRAGMIDIUM (INCOMPLETE.)

4. PHRAGMIDIUM INCOMPLETUM, nov. sp.

On *Rubus paniculatus*, Smith.

In March I found the leaves of this host bearing the uredospores (aecidiospores ?) of some species of *Phragmidium* probably, which I have not been able to determine, never having seen the teleutospores. It was found in a deep valley near Simla. The nerves of the leaves were mostly attacked, and in such places they were distinctly hypertrophied: a few pustules were also found, however, upon the blade proper. The pustules were entirely hypophyllous, but their places were indicated on the upper surfaces of the leaves by reddish brown spots of discolouration. The pustules were light yellow and small.

The spores are yellow, round to oval, beset with prominent spines, and measured when fresh $34 - 30 \times 25 - 23\mu$. There are no paraphyses. They germinated readily in water, throwing out single long unbranched straight tubes, mostly aerial.

Remarks.—In this incomplete stage it is impossible to identify it with any known species.

MELAMPSORA AND COLEOSPORIUM.

I have found considerable difficulty in separating certain Uredines into *Melampsora* and *Coleosporium*, mainly because I have not been able to observe the germination of the teleutospores sufficiently accurately. Apart from this, however, the morphological characters of each group are sufficiently definitely set forth in Winter's work* to enable one to separate them with confidence, were these characters maintained in each species. For example, it is stated that in the genus *Melampsora* the teleutospores are single-celled, or vertically divided, rarely horizontally, and that the uredospores are borne singly on basidia; whilst in the genus *Coleosporium* the teleutospores consist of several, usually four, superimposed cells, and the uredospores are in short chains. But in the case of the Simla forms these characters are not separately maintained, for whilst in some species the teleutospore forms conform with the description of *Melampsora* spores the related uredospore forms resemble *Coleosporium* forms. This is the case, for example, with the parasites on *Hypericum* and *Leptodermis*. In these species the teleutosporic forms are distinctly of the *Melampsora* type, whilst the uredos being in well defined chains, resemble *Coleosporium*. As the teleutospores are the more important I have considered these forms species of *Melampsora*.

* "Die Pilze Deutschlands," &c.

In only one species, namely, that on a species of *Salix*, do the characters of the teleutospores and uredospores coincide with the descriptions given by Winter. This would appear to show that the distinctive characters of the uredospore formation in the two genera as usually given, are not of generic value. Lastly, I would draw special attention to the formation of spermogonia in one of these fungi, namely, on *Hypericum*. So far as I am aware the existence of this form of fructification has never yet been observed in any other species either of *Melampsora* or of *Coleosporium*.

MELAMPSORA, Castagne.

a. HEMIMELAMPSORA, Schröter.

1. Melampsora Sancti-Johannis, nov. sp.

On *Hypericum cernuum*, Roxb.

This is a very remarkable parasite, causing very noticable abnormalities in the host; for not only are its leaves sometimes covered with conspicuous localised patches of discoloration, but whole shoots are often involved (fig. 3, Pl. II). In the latter case the shoot is, before the formation of teleutospores, of a sickly pale yellowish green colour; often hypertrophied when quite young; but this hypertrophy is masked later on by arrested growth of the shoot, and the normal shoots of equal age continuing to grow throw the attacked shoots out of comparison. The leaves borne by such attacked shoots are always considerably smaller than healthy ones. The fungus in one form or another is to be met with almost throughout the year upon the living host. It is extremely common in this neighbourhood, and plants are often met with completely eaten up with it. The normal course of the fungus through the year is as follows:

In early spring (March) both the localised leaf patches and wholly involved shoots are abundantly met with; but the latter are always more abundant than the former. In April some uredo pustules are formed on both localised patches and on the leaves of wholly involved shoots; but much oftener on the latter. These pustules are, however, very uncommon, and must be looked for diligently. I have found them only in April. During the time uredo pustules are formed spermogonia also are found on the same leaves. These are mainly epiphyllous, though a few may be found also on the lower surface. The uredo pustules are minute circular pale yellow sori, mostly hypophyllous. After April there is a cessation of activity in the reproduction of the fungus until July. In this interval, however, if from unusual wet weather new shoots are formed by the host, some of them are found

attacked. Under similar circumstances a few localised patches are also found; but as a rule the interval is one during which the fungus is comparatively rare. Early in July, after the commencement of the rains, the host puts forth new shoots abundantly, and many of these are then found to be wholly attacked; localised patches are very rare, and almost entirely absent. The September, towards the end of the rains, localised patches are again formed, and become fairly abundant, though not so abundant as in spring. Lastly, from October to spring the fungus is again rare in both forms; and, indeed, in the depth of winter (December to February) it may be said to be absent.

The localised patches are found on quite healthy leaves. When quite young they are circular, very conspicuous, especially on the upper leaf surface, from their yellowish green colour, and measure about 5 m.m. in diameter. The edge of the patch above is often surrounded by irregular reddish brown spots. The patches in time increase considerably in area. A single leaf may contain from 1 to 8 such patches.

The leaves of wholly involved shoots are generally covered on their under surfaces with irregular beds of a brownish orange to deeply orange colour, forming diffused blotches, which often in time coalesce, and uniformly cover the whole of the lower leaf surface. A few such blotches sometimes occur on the upper surface also; but rarely.

The *uredospores* are given off in short chains, and there are no paraphyses among them (fig. 2, Pl. II). They simply burst through the epidermis, a fray of which may be seen on the margin. The whole depth of the uredo bed is about 0·100 m.m. They are very irregular in size and shape, pale orange or yellowish red in colour, with an epispore finely tuberculated. They measure when fresh and examined in water $25{\cdot}3 \times 21{\cdot}7\mu$ on an average, varying from 22×20 to $30 \times 28\mu$. After lying many hours in water they measure $38 \times 30{\cdot}8\mu$ on an average, varying from $25{\cdot}2$ to $44{\cdot}1\mu$ in diameter. They germinate in water, but not readily, throwing out a simple germ tube. In transverse sections three to four ripe spores may generally be seen in a row, with as many immature ones below. It is noteworthy that in fully involved leaves from wholly attacked shoots there is no differentiation of the leaf tissue cells into palisade and spongy cells: the former are, however, quite typical in normal leaves (fig. 2, Pl. II).

The *teleutospores* are formed beneath the epidermis, which is gradually lifted and disorganised, laying the spores bare. These beds, when just formed, are seen in transverse sections of leaves to be very slightly elevated above the general epidermis level. The depth of such a bed is about 30μ. When transverse sections of leaves through teleutospore beds are kept in water the spores germinate, throwing out a simple

promycelial tube, measuring 4 to 6μ in diameter, which bears a sporidium 6μ in diameter. The teleutospores are long very narrow cells, very densely packed together side by side (fig. 1, Pl. II); so much so that in section the spores are polygonal. Each spore is about 26μ long and 6 to 8μ broad. The spores are never horizontally divided but are sometimes obliquely divided. Fig. 4, Pl. II represents a surface view of portion of a spore bed. It will be seen how small they are in diameter.

The *spermogonia* are large flat structures, very frequently contiguous to a uredo pustule. They measure from 0·252 to 0·346 m.m. in width, and 0·126 to 0·144 m.m. in depth, and their bases rest upon subepidermal tissue (fig. 2, Pl. II). They appear to have no tuft of paraphyses protruding, at least I saw none in the numerous permanently mounted preparations I made and examined.

Remarks.—This is evidently distinct from *M. Hypericorum* (D. C.) as both the uredo- and the teleutospore beds are large and extremely conspicuous, whilst those of the European species are said to be very inconspicuous and small.

2. Melampsora Leptodermis, nov. sp.

On *Leptodermis lanceolata*, Wall.

Early in August the leaves of this host discover small saffron yellow uredo pustules on the lower surface, with pale yellow spots on the upper surface opposite them. The leaves are generally extensively bespattered with these pustules.

The *uredospores* are given off in chains (fig. 6, Pl. II), and are orange yellow (more yellow than orange), round, or slightly oval, beset with prominent spines. The fresh spores examined in water measure 25 × 20μ. I did not observe their germination: they refused to germinate in water on the several occasions I examined them. There are no paraphyses among the uredospores.

At the same time some bright orange red, more or less waxy looking beds may be seen interspersed among the uredo pustules, which are the *teleutospore beds*. The uredo stage is quickly over, and towards the end of August only teleutospore beds are found. These beds rest on the subepidermal cells. They are formed below the epidermis, which they gradually lift up and disintegrate. In transverse sections through newly formed beds it is seen that they are somewhat elevated above the general epidermis level. Such young beds measure about 30μ in total depth, 18 of which is above the outer surface of the surrounding epidermis. This elevation continues as the bed grows older, until at last its base is on the level of the outer surface of the epidermis.

The *teleutospores* are brilliant orange yellow in colour, and are usually single celled, and somewhat thickened at the free end, and the whole bed is covered externally with a thin hyaline layer (fig. 5, Pl. II). Each spore measures about 13μ in breadth, and 30 to 35μ in length: each usually displays a clear nucleolar space. When a portion of leaf blade containing teleutospore beds is kept in a moist atmosphere the latter are found after some hours covered with minute orange red hairs, just distinguishable with the naked eye. These are the promycelial tubes which each bear a very large oval deeply orange red sporidium, measuring about 27 by 15μ, attached asymetrically to the sterigmata. These sporidia germinate readily in water throwing out a simple germ tube, into which the orange red contents wander. As affected bushes have usually immense numbers of pustules on almost every leaf I thought there might be a perennial mycelium; but an examination of the stem bearing numerous such leaves showed no trace of mycelium.

A very remarkable peculiarity in this fungus is the occurrence of hypertrophies on the leaves and smaller stems, bearing *Puccinia* pustules. It is so extraordinary that one is inclined to believe that it is an accidental association of two parasitic fungi, each perfectly independent; and this view commends itself the more favourably when I note that I never found these *Puccinia* hypertrophies on any other than one particular bush. On this bush, however, I collected many, and a few of them were on leaves bearing immense numbers of *Coleosporium* teleutospores. As the *Puccinia* were so intimately associated with the *Coleosporium* I will note its characters here, leaving the final determination of accidental association, or relationship, to future biological experiment.

I found these *Puccinia* hypertrophies on the 7th August, when the *Coleosporium* is in full growth, on the stem, petiole, and leaf blades. The hypertrophies were studded with black pustules containing *Puccinia* spores. The spores are firmly adherent, and when scraped off appear brownish yellow to the naked eye. By transmitted light they are pale brownish yellow bodies, with thin walls, and very clearly defined nucleolar spaces in each cell. They are clearly, though not deeply, constricted at the septum; sometimes with a slight apical thickening, but oftener not. Externally they are smooth (fig. 7, Pl. II). The fresh spores examined in water measured from 42 to 47μ in total length, and 20 to 24μ in breadth at the septum, which divides the spore into two almost equal halves. The stalks adhering to the scraped off spores are very long, measuring in diameter 5μ at the far end to 10μ at the insertion into the spore. I placed these spores into water with a view to observing their germination: but they do not germinate apparently until after a period of rest.

3. Melampsora Salicis Capreæ, (Pers). ?

On *Salix*, sp.

In April I found this host attacked by a uredo-bearing fungus, but by no means largely. Young shoots were attacked, and in such cases every leaf bore beds. The uredo pustules were extremely numerous on each leaf, and on the lower surface mostly, with only a few on the upper surface. These are round or oval and prominent (hemispherical). The spores are pale yellowish orange, and very deciduous, and each pustule contained club-shaped paraphyses (fig. 8, Pl. I). The spores were very uniform in size and round, measuring 20μ in diameter when examined fresh. The epispore is coarsely tuberculated and the contents granular. I placed these spores in water in a watch glass, but they did not germinate.

After this I lost sight of the fungus until July, when I saw the same host in the same locality much more extensively attacked, probably by the same parasite. Now the leaves were more generally attacked, not as before only leaves on particular shoots. The leaves exhibited patches of discolouration, blackish brown in the centre with a surrounding zone of brownish red, and lastly the whole surrounded by an irregular zone of pale yellow. On the lower surfaces of such patches spore beds were erupted. On the blackish centre there was usually a central pustule, surrounded by a circlet of others ; and beyond this circle, and outside the blackish centre, irregularly disposed small yellow pustules. The spore beds everywhere contained the same uredospores, with very large club-shaped paraphyses surrounding the base, and sparsely also among the spores. A uredo bed may often be seen in the middle of teleutospore beds. The uredospores are not given off in chains but are borne singly on stalks (fig. 8, Pl. I). These spores are oval, and beset sparsely with coarse spines. The fresh spores measure 28 × 22μ, on an average. The heads of the paraphyses are smooth.

Again in September I found the leaves bearing teleutospore fructification. The leaves were now speckled irregularly on their lower surfaces with orange red spots, mostly round but sometimes of an irregular shape from the coalescence of pustules. With a field lens a central cushion of spore beds may be seen, about 2 to 3 m.m. in diameter. On the upper leaf surface these invaded areas are dark red and very conspicuous. Individual leaves are often very extensively attacked. The central spore cushion contains uredospores with extremely large capitate paraphyses. The spores are very pale yellow and echinulate, oval to round, 23μ in diameter to 26 × 21μ. The heads of the paraphyses measured 27μ in breadth by 34μ in length. The teleutospores in mounted specimens, after treatment with alcohol, measure from 34 to 54μ in length and 8μ in breadth.

Remarks.—I have thought it best to name this fungus *M. Salicis Capreae;* but further research may show it to be different.

COLEOSPORIUM, Léveillé.

HEMICOLEOSPORIUM, Schröter.

1. Coleosporium Plectranthi, nov. sp.

On *Plectranthus Gerardianus*, Benth.

This host begins to be attacked towards the end of July, and in August is in the uredo stage. The pustules are entirely hypophyllous, and consist of little yellow heaps of the size of an ordinary pin's head. The pustules sometimes exhibit a circinate tendency. The position of pustules above is indicated on the upper leaf surface by yellow areas, irregular in size and contour. Some leaves have very numerous areas of invasion, whilst others have but very few. The *uredospores* are very pale yellow, oval, densely tuberculated, measuring on an average when fresh and in water 24 × 17μ. The epispore is very thick; but I could not detect any germ pores. They are given off in fairly long chains.

Around these uredo pustules, early in August, some indistinct smears of orange red colour may be seen, the commencing teleutospore beds, and these rapidly acquire prominence. At the end of August teleutospore beds are very numerous: they are strictly hypophyllous on the uredo areas of invasion. The beds are bright orange red waxy looking cushions. A uredo pustule is often, though not always, the centre of a concentric arrangement of teleutospore beds. At the end of August I put some uredospores and some sections of leaf blade through teleutospore beds into water. The former did not germinate, probably because they were too old; but the latter produced a few oval sporidia. I was unfortunately unable to make out the exact morphological form of the promycelium; but as far as I could see it was of the nature of a *Coleosporium* one. The teleutospore beds are covered with a well marked hyaline layer, and the top of each spore often presents a globular mass of the same hyaline substance. The spore cells are usually single but sometimes divided into two or three parts. The whole length of a spore is about 24 to 28μ, and in breadth about 12 – 14μ, (fig. 4, Pl. IV).

2. Coleosporium Clematidis, nov. sp.

On *Clematis montana*, Don.

Clematis Buchananiana, D. C.

A *Coleosporium* on *Clematis montana* is not infrequently found about Simla during August to October: it is not, however, common in the

neighbourhood of the station. Deep orange red waxy looking beds are formed on the under surfaces of the leaves, frequently circinating round a central uredo pustule of much paler and more yellow colour. A single leaf may bear numerous such pustules. On the upper surface the position of these beds below is indicated by irregular patches of paling, not of definite outline or shape.

The *uredospores*, given off in chains, are orange red, densely beset with large tubercles, and measuring when fresh 30 × 20μ on an average; but varying a good deal in individual measurements.

The *teleutospore beds*.—In *Clematis montana* the teleutospores are usually divided into four cells by transverse septa (fig. 3, Pl. IV). The average length of each spore is about 50 to 60μ and 12 to 14μ in breadth. A single sporidium is formed by each cell on a long narrow sterigma (fig. 5, Pl. IV). The spore beds are initially formed beneath the epidermis.

A little later (September) a similar parasite may be found on *C. Buchananiana*; but I am not certain that it is of the same species. In the absence of biological data it may be regarded provisionally as the same. The circinate arrangement of teleutospore beds around central uredo pustules is not observed on this host. The uredo pustules are saffron yellow, and scattered irregularly over the lower surface of the leaf.

The *uredospores*, here also given off in chains, are pale yellow, tuberculated, and measure when fresh 27 × 22μ.

The *teleutospore beds* are brick red, and occur here and there amongst the uredo pustules, which are at the time I got specimens (September), much more numerous, the reverse being the case in the former host. These beds form, as above, elevated cushions on the surface, above the level of the epidermis. In transverse sections the free surface is seen to be covered with a thin hyaline layer, about 25μ in depth. In such sections the palisade layer of cells on the opposite side are seen to be undisturbed. The whole depth of the teleutospore beds in fresh sections examined in water was found to be about 0·189 m.m. Each teleutospore in this host is larger than on the former, measuring about 80 to 100μ in length by 14μ in breadth. Moreover the spores on this host are usually not divided, but sometimes into 2 or 3 parts.

3. Coleosporium Campanulae, Pers.

On *Campanula colorata*, Wall.

Even as early as the 6th February (1889), a few days after the snow had melted, I found this host bearing brilliant orange red uredospore pustules. At this time only the young lowermost leaves and their

petioles were thus attacked, the pustules breaking out from both surfaces of the leaf blade. At this time I found that the uredospores germinated freely in water, throwing out a simple long tube (about 200μ in length, and 5μ in diameter), into which the coloured contents of the spore wandered, leaving the walls of the latter colourless. In March this stage is still common, but now the sori are more frequently erupted from the lower surface of the blade, a few pustules occurring on the upper surface, exactly opposite some below. Still only the lower leaves near the ground are attacked. The sori on the lower surface tend to coalesce now. Towards the end of March the uredospores do not germinate so readily in water. The fungus is then missed to general observation until early in July, when a new crop of uredo pustules attracts attention. These are numerously erupted from the upper leaf surface, and now from the upper leaves on the stalks. At the same time such attacked plants usually exhibit some generally paled lower leaves, on the lower surfaces of which waxy orange red elevations may be seen, which are teleutospore beds. The same leaves usually bear a few uredo pustules as well. This stage continues throughout August; but the teleutospore beds increase in numbers whilst the uredo pustules diminish and become very scarce, though never entirely absent. At the end of September a third crop of uredo pustules is produced, now all over the green parts of the plant, ascending to, and involving even the green parts of the flower and young fruit capsules. Shortly after this the host withers and dries up. From July onwards the teleutospore beds are constantly met with.

The *uredospores* of all three crops are alike, both in measurement and in general appearance (fig. 10, Pl. IV). They are given off in chains, are orange red, thick walled, beset with tubercles, and measure on an average 21 × 17μ; but after lying in water for 12 to 24 hours 25 × 18μ. Each spore appears to have three germ pores.

The *teleutospores* are covered by a well marked hyaline layer. The spores are orange red and are divided by transverse septa into 3 to 5 cells (fig. 2, Pl. IV). The average length of each complete spore is 40 to 45μ, and the average breadth 14μ.

Remarks.—I have named this species provisionally *C. Campanulae;* but it should be noted that both the uredo- and teleutospores are smaller in the Simla species; neither are the uredospores so variable in size and shape as they appear to be in the European species.

GYMNOSPORANGIUM, Hedwig f.

1. Gymnosporangium Cunninghamianum, Barclay.

On *Cupressus torulosa*, Don.

And *Pyrus Pashia*, Ham.

For a detailed description of this, the only species of *Gymnosporangium* in this region, I must refer the reader to a paper on its life history in the "Scientific Memoirs by Medical Officers of the Army of India," Part V, 1889.

The aecidial stage I have already described in a former volume of this Journal* under the name *G. clavariaeforme*, as at that time its characters appeared to me to agree most nearly with those of that European species. Since the discovery of its complete life history, however, I have no doubt that it is a distinct species, and I have renamed it as above.

The teleutosporic stage on *Cupressus torulosa* may be described as follows. The teleutospore beds are hemispherical dark brown compact bodies during dry weather, and are formed on the ultimate small branches as well as on twigs of 4 to 5 m.m. in diameter. During moist weather these beds swell up enormously into gelatinous masses, which quickly assume a yellow ochre colour, due to a rapid formation of sporidia. During heavy rain the gelatinous spore masses fall to the ground.

The *teleutospores* are slender spindle shaped yellow bodies on long stalks covered with a substance capable of swelling greatly when moistened. When the spore becomes detached from the stalk after moistening a characteristic disc remains at the place of junction. There is no appreciable constriction at the septum, and the walls are usually uniformly thick, with sometimes a slight thickening at the apex. The spores when scraped off dry beds and examined immediately in water measure $75{\cdot}6 \times 25{\cdot}2\mu$. Each cell of the spore has two germ pores near the septum. They germinate very readily in water: a promycelium is formed by each cell, dividing into four parts, each forming a sporidium on stout sterigmata. The sporidia are orange red, oval, measuring from 15×9 to $22 \times 14\mu$. The formation of secondary sporidia is not uncommon. Experimental evidence fully confirmed the genetic relationship between these teleutospores and the aecidial form on *Pyrus Pashia*.

* J. A. S. B., Vol. LVI, Pt. II, No. 3, 1887.

CHRYSOMYXA, Unger.

LEPTOCHRYSOMYXA, Schröter.

1. Chrysomyxa Himalense, Barclay.

On *Rhododendron arboreum*, Sm.

A detailed description of this fungus will be found in the "Scientific Memoirs by Medical Officers of the Army of India," Part V. It is an extremely conspicuous parasite, since it gives rise to witches' brooms on the host, and is very abundant. The fructification of the fungus may be seen from early spring to the end of May. This has its seat especially on the petioles and along the midribs a short distance into the leaf blade. When ripe the fruit bodies, which are orange red, clothe the petioles so densely as to hide it completely. Each separate fruit body is club-shaped. The expanded upper part measures on an average 2 m.m. in diameter, and the whole about 1·5 m.m. in length. These fruit bodies are also occasionally found on the main axis of shoots and as isolated groups on the leaf blade. In a moist atmosphere they become pure yellow from rapid sporidial formation. These fruit bodies are found only on the leaves and stems of the previous year's growth; never on the newest. The shoots attacked are dwarfed in growth, and bear smaller leaves than normal. There are no uredospores.

Localised attack of the leaf blade is not common. When it occurs, always on leaves of the previous year's growth, small patches are formed reddish brown above with a cluster of about 25 fruit bodies on the lower surface. The leaf blade at such places is very slightly thickened.

The mycelium in the stem is perennial. It is of the usual characters, contains an abundance of orange red oil globules and forms haustoria.

The fruit body consists of four parts: (*a*), the primary lowermost stalk cells, forming the stalk of the club-shaped fructification: (*b*), a group of large central cells, three to four in each row, usually forking, and forming the main part of the expanded club end of the fruit body: (*c*), secondary stalk cells, branches of the last, which give rise to promycelia: and (*d*), the promycelia proper, measuring about 50μ in length by 10μ in breadth, and dividing into four cells, each of which produces a sporidium at the end of a narrow sterigma. The sporidia are round or oval, orange red, and measure from 9μ in diam. to $12 \times 10\mu$. The sporidia are thrown off forcibly as in the case of *C. Rhododendri* (D. C.).

2. Chrysomyxa Piceae, nov. sp.

On *Picea Morinda*, Link.

I first found this parasite in June at Narkanda (40 miles from Simla) where it is fairly, though by no means very, abundant; but I have since found it fairly common much nearer, namely, at Mashobra, a suburb of Simla. In Simla itself I have never met with it on the comparatively few individuals of the host which are present. At Mashobra I found numerous trees attacked with it in the middle of May, and some very extensively. The upper sides of the needles bore brilliant orange red convex beds, round or oval to oblong. Each needle usually bore several such beds; but varying from 2 or 3 to 16, mostly in a single row. Sometimes, however, there was an imperfect parallel row on the other side of the upper needle surface. I observed that in most trees almost all the beds were on one particular side of the needles, so that they could be much better seen from one side of the tree than from the other. This was probably due to some light effect?

Thus the usual site of eruption is the upper half of the needle surface; but sometimes beds are extruded from the lower side also. In the immediate vicinity of the beds the needles were very slightly paled or yellowed, but very inconspicuously. These fruit bodies occur mostly on the older needles, and by far the most frequently on two-year old needles, and were never present on the youngest just evolved needles. I never found any on the axis. The beds varied from about 0·6 m.m. in diameter to 2·5 or 3 m.m. in length by 0·6 m.m. in breadth. In depth (*i. e.* from the free end to the base on the subhypodermal tissue they usually measured 0·44 m.m.).

The mycelium ramifies among the chlorophyll containing cells between the hypoderma and the endothelial sheath, but appears never to penetrate within the latter. The hyphae are on the whole sparingly distributed, except at the bases of fruit bodies where they are very abundant. They are easily seen in fresh sections as they contain orange red oil globules, and measure 4μ in diameter. The resin canals never contain hyphae; but these are sometimes seen in the air spaces below stomata.

The *fruit body* consists mainly of radiating long oval cells, borne by much septated filaments forming a pseudo-parenchyma. These long cells measure from 0·100 to 0·157 m.m. by 12 to 16μ broad. They may frequently be seen to contain a central well marked nucleus, staining deeply with carmine. These cells are never forked (fig. 1, Pl. IV.) There are a few scattered cells beyond the outer ends of the long cells, on the surface of the fruit body, but they do not appear to

be portions of a promycelium. Unfortunately I have never been able to see any sporidial formation. I have kept needles bearing the fructification in a moist atmosphere, but without seeing any germination. My description of this parasite is therefore very imperfect.

Remarks.—In comparing this fungus with Rees's description of *Chrysomyxa Abietis*, Ung, there appear to be considerable differences, and especially in the large cells forming the main elements of the fruit body. I have examined numerous sections, but have never seen these cells septated, nor forked. It would therefore almost seem that the parasite is more nearly related to *Coleosporium* than to *Chrysomyxa*. The want of observation of the nature of germination unfortunately precludes any decision on this point, and I have included it among *Chrysomyxata* on general rather than on particular analogy. Should future research show that it is in fact a *Chrysomyxa* it would be an interesting example of the very close morphological relationship between this genus and *Coleosporium*.

Among other points of difference may be noticed the larger size of the teleutospore beds in the European species, the smaller number of them on each needle (one to two), their eruption from the *under* surface of the needle, the conspicuous yellow bands of discolouration produced on the needles, the smaller number of teleutospore cells on each fruit body (about 12 against 20 in Simla), and the presence of haustoria.

CAEOMA, Link.

1. Caeoma Smilacis, Barclay.

On *Smilax aspera*, L.

For a detailed description of this parasite I must refer the reader to a paper on its life history in the "Scientific Memoirs by Medical Officers of the Army of India," Part IV. It is apparently a complete autoecious species, but the experimental evidence for this is not complete.*

The *aecidial stage* is found in July on the newly evolved leaves and their petioles. Bright yellow patches are formed on the leaves, more or less irregular in shape, and varying in size from a small point to 2 cm. in diameter. These patches are considerably thickened. When mature such patches bear minute brownish papillae on both surfaces, which are the aecidia. The latter open by a pore, through which the aecidiospores are extruded. These patches also bear spermogonia mostly on the upper leaf surface.

In October, when the aecidial stage is disappearing, the same generation of leaves bear *uredo pustules*, formed by a distinct mycelium.

* Since this paper was read I have completed the evidence.

The lower surfaces of the leaves exhibit a few or a very great many slightly paled circular areas on each of which a minute pustule is formed, containing yellowish brown uredospores. The invaded areas are not in the least thickened. When a leaf is not excessively attacked the uredo pustules frequently exhibit a marked circinate arrangement, two circles around a central pustule.

The *teleutospore stage* consists in the gradual production of *Puccinia* spores in the uredo pustules, which latter then enlarge very greatly. The teleutospore beds are well raised dark brown compact masses. If a leaf bearing teleutospore beds be placed in a moist chamber the beds swell very noticeably, and become light brown in colour. This swelling is due to the swelling of a gelatinous sheath enclosing the stalks of the teleutospores.

The *mycelium* bearing uredo- and teleuto-spores does not contain orange red oil globules, does not form hausteria, and does not give rise to any hypertrophy of the host's tissues. That bearing aecidia contains conspicuous coloured oil globules and gives rise to considerable hypertrophy of the host's tissues; but still does not form haustoria.

The *uredospores* are oval or pyriform, pale yellow, and beset externally with very prominent spines. Among them are a few club-shaped paraphyses. They are formed singly on short stalks. The fresh spores measure on an average $46{\cdot}5 \times 31{\cdot}7\mu$. The epispore is thickened at the free end. They do not germinate readily in water, and I have consequently not observed their germination with accuracy.

The *teleutospores* are pale yellow, with long stalks surrounded with a gelatinous sheath. The free end is thickened. They vary in length from $74{\cdot}0$ to $50{\cdot}8\mu$: the upper cell varies from 38×16 to $25 \times 15\mu$, and the lower from 36×16 to $25 \times 15\mu$. The spore is slightly constricted at the septum, and measures about 14μ in breadth. They are firmly adherent. The epispore is smooth. When the stalk is swelled in water the thin central axis is clearly defined as in *Gymnosporangium*. The spores germinate by forming two usual promycelia, but instead of forming sporidia on sterigmata, the four cells of each promycelium separate from one another, and apparently represent sporidia. These detached cells measure from 14×8 to $18 \times 11\mu$. I never observed these cells germinating. At the time I wrote the paper referred to above I had never witnessed any variation from this mode of germination. At that time all my cultivations were made in hanging drops of water in a confined atmosphere. Recently, however, I caused the teleutospores to germinate in water in a watch glass, in a large moist atmosphere (as recommended by Plowright), and then the usual sporidial formation took place. The sporidia are oval and orange red and measure from 10μ in diameter to $18 \times 8\mu$.

The *aecidium* is deeply placed and is not bounded by any peridium, but by a layer of convoluted hyphae. The aecidiospores are given off successively from basidia, but ripe spores do not remain attached to one another in rows as usual. As each spore ripens it is cast off, and the spore below, which up to this time remained in a rudimentary condition, then grows rapidly, forming another ripe spore, and so on. The spores are pale yellow, mostly oval, with an epispore of variable thickness, thickened at one end, and beset with large coarse spines, which are deciduous. The fresh spores measure 43·2 × 25·6μ on an average, varying from 36 × 28 to 52 × 16μ. The thickness of the epispore is usually about 4μ, and 6 to 10μ at the thickened end. These spores, like the uredospores, do not germinate readily in water.

The *spermogonia* are plentiful, are deeply set, and a tuft of paraphyses protrude through the mouth. They measure 145μ in depth, and 157 in breadth.

2. Caeoma Mori, nov. sp.

On *Morus alba*, L. var. *θ. serrata.*

This fungus is one of those species situated so nearly between two genera that it is somewhat difficult to decide to which it belongs. On the whole I am inclined to regard it as a species of *Caeoma.*

Curiously enough I only once found it, namely, in November, 1885, and although I have frequently searched for it again I have never succeeded in finding it. Owing to this circumstance my notes of it are very imperfect.

The aecidia are hypophyllous. Although there is no regular coherent peridium the outer aecidiospores resemble peridial cells in being colourless and larger than the aecidiospores proper (fig. 6, Pl. IV), which are reddish yellow, round or oval, and measuring when fresh from 14μ in diameter to 20 × 14μ, but on an average 17 × 14μ. The epispore is thick, measuring 2μ. The outer colourless pseudo-peridial cells measured from 19 × 11 to 22 × 12μ.. I did not observe the germination of the aecidiospores.

ISOLATED UREDO FORMS.

Of isolated Uredo forms six are known to me. Among these two are remarkable, namely, those on *Vitis himalayana* and on *Gomphrena globosa*, the former for forming columnar spore masses, and the latter for producing a curious flocculent mycelium on the surface of water when allowed to germinate there in a moist atmosphere.

1. Uredo Eupatoriae, (D. C.) ?

On *Potentilla* (*Kleinicura*, W. and A. ?)

This host may sometimes be found in July extremely attacked by a uredo bearing fungus. Brilliant orange red or yellow pustules may be found in great numbers on the stem, leaves, petioles, bracts, and even fruit. The spores are brilliantly orange red, irregularly round, beset externally with spines or tubercles, measuring on an average 20μ in diameter when fresh. When placed in water they germinate readily, and normally like uredospores.

2. Uredo Bupleuri, nov. sp.

On *Bupleurum falcatum*, L.

In September this may be found attacked. Numerous minute brown circular pustules are borne on the lower leaf surface, with some irregular discolouration on the opposite or upper leaf surface. The host is at this time in full flower. The spores are brown, round, measuring when fresh 20μ in diameter, with an epispore studded with shallow warts, and with three germ pores usually, but sometimes four. When placed in water they germinate readily in the usual manner of uredospores. Though I have examined pustules up to the time the host dies and is withered up I never saw any other form of spore.

3. Uredo Cronartiiformis, nov. sp.

On *Vitis himalayana*, Brand.

This host is very extensively attacked with a peculiar uredo-like affection, suggestive of *Cronartium*, since the spores are aggregated together into small cylindrical columns, with numerous curved paraphyses at the bases of the columns. The whole, column of spores and paraphyses, are borne on minute papillae on the lower leaf surface. The column of spores is about 1 to 2 m.m. in length, and 0·19 to 0·25 m.m. in diameter.

The parasite is first met with towards the end of July, but continues to increase in abundance until the leaves fall off in autumn (October and November). The pustules are exceedingly small, and are distributed in immense numbers all over the lower surface of the leaf blade. The upper surface of the leaf is studded with reddish brown stains, which makes this otherwise inconspicuous fungus remarkable.

When these columnar heaps of spores are scraped off, which may very easily be done with a light touch, and placed in water, they readily break up into their component elements, and the weight of a cover glass

immediately dissociates the spores. Even when a leaf bearing these columns is first hardened in absolute alcohol the columns do not attain any greater coherency.

The individual spores are obovate or club-shaped, and fairly densely covered with spines. They are pale orange yellow, and measure about 30 × 18 to 27 × 18μ when fresh (fig. 9, Pl. IV).

The earliest formed pustules are yellowish in colour, but later, at the end of August, when the fungus is extremely common, the pustules are brown. The leaves are now old and this may be the sole reason, for the spore columns and spores are identical in size and structure, though the latter are also brownish now. Placed in water the spores of both colours germinate similarly, exactly like uredospores, and very readily, even up to the middle of October.

In August, when the parasite is beginning to appear, I tied some leaves bearing yellow pustules to a plant in my garden which was quite healthy, and in September many of its leaves were studded with similar yellow pustules.

Although I looked carefully and continuously for some teleutosporic form I never found any trace of such.

4. Uredo Apludae, nov. sp.

On *Apluda aristata*, L.

This grass harbours a uredo bearing fungus towards the end of September, but I have never found any teleutospores on it. The uredo pustules are brown, small, oval to linear, very inconspicuous in that it gives rise to no appreciable discolouration in the blade, and entirely hypophyllous. The spores are round to oval, pale brown, thick walled, and measure when fresh 22 × 20μ on an average. Some few are much larger, *viz.*, about 30 × 21μ. The epispore is densely beset with minute tubercles, and has four germ pores. At the end of October I found the same pustules even on drying leaves.

5. Uredo Gomphrenatis, nov. sp.

On *Gomphrena globosa*, L.

Late in October this host is largely attacked in certain localities only. In such places the lower surfaces of the leaves are often densely besprinkled with dark brown, minute, circular pustules, whilst only exceptionally are some found on the upper leaf surface. The upper surfaces of attacked leaves are very slightly paled opposite spore beds on the other side. Spore beds are also formed on the stems and are here linear or oval. The spores are very deciduous, and there are no para-

physes. The uredospores are spiny and yellowish brown, and fall off without any portion of the stalk adhering, although the place of attachment to the stalk is generally very noticeable (fig. 8, Pl. IV). The walls are generally uniformly thick, but in some cases with a very slight apical thickening. The fresh spores examined in water measure on an average 35 × 26·2μ, varying from 32 × 27 to 40 × 24μ. Each spore has two germ spores. When placed in water these spores germinate at once most freely, forming immensely long germ tubes, so long that if numerous spores are floated on water in a watch glass in 24 hours a white silky mould appears to have been formed by them. In germination they are typical uredospores. I never found any teleutospores though I looked carefully for them until the host withered in winter.

6. Uredo Deutziae, nov. sp.

On *Deutzia corymbosa*, Br.

I found this host attacked with a Uredo-bearing fungus in June. The pustules are very pale yellow, hypophyllous, on paled circular areas of the leaf. They are numerous on each leaf. Each pustule, of which there are many on each discoloured patch, is minute and hemispherical. The upper leaf surface is paled opposite the spores below. In general appearance they resemble the Uredo pustules of *Melampsora* or *Coleosporium*. The spores are pale orange yellow, sparsely spiny, round to oval, and measuring 25 – 22 × 21 – 18μ, after lying 24 hours in water.

Remarks.—I found fungus while this paper was passing through the press and I have been unable therefore to illustrate it in the plates. I have not had an opportunity for observing its further development, and must class it meanwhile with isolated Uredo forms. It may possibly be *U. Hydrangeae*, Berk. et Curtis.

ADDENDA.

In the first portion of this list of Uredines* containing a description of the Aecidial forms I noted that I would defer a description of the two forms occurring on *Pinus longifolia* and *P. excelsa*, as my notes of them were at that time incomplete. Descriptions of them now follow. In addition to these I have noted the characters of other two isolated Aecidia.

Since the publication of the second part of this list,† dealing with

* Journal of the Asiatic Society of Bengal, Vol. LVI, Pt. II, No. 3, 1887.

† *Ibid*, Vol. LVIII, Pt. II, No. 2, 1889.

the *Puccinia*, I have discovered six other species, all on the higher *Phanerogamia*, most of them apparently new.

1. Aecidium complanatum, nov. sp.

On *Pinus longifolia*, Roxb.

This *Aecidium*, on the needles of *Pinus longifolia*, is extremely common in Simla, and, indeed, it is rare to find the host free from it. I have once only seen it on the stem (var. *corticola*) and my further remarks refer only to the variety on the needles. The *Aecidium* may be found from autumn to June. A minor crop of aecidia is produced in November on the needles developed in spring, and although numerous in certain localities is not by any means so abundant in general as a second crop which commences in February and which gradually reaches a maximum development in May. The crop commencing in autumn is associated with well marked spermogonia, while that commencing in February is apparently without them.

The needles of the host are annual in this region falling from May to June, that is just before the rains set in. At this time the new needles are emerging from their brown scaly covering, and are about 2 to 3 inches long, and, growing rapidly, entirely replace the needles of the year before in July. (I should here mention that a minor evolution of young shoots and needles occurs in autumn, about November). These newly developed needles bear no sign of attack until the middle of August, when many of them, in favoured localities, may be seen bearing paled areas with spermogonia, which long precede the eruption of peridia. After May the dying needles still adherent may still of course be seen bearing peridia; but these are old, and are either empty or contain only a remnant of aecidiospores. In July, when all the old needles have fallen, there is no vestige of the parasite left.

The *aecidia* are large, flat, prominent bodies, reddish yellow in colour, and borne on paled portions of the needles. Each needle bears from 1 to 8 peridia, mostly on the lower or lateral surface. Their length coincides with the long axis of the needle and is very various. The peridia are usually about 1/5th inch (5 m.m.) in length, but are sometimes as much as 1/2th an inch (12·7 m.m.) in length, and in height from the surface of the needle 1/10th inch (2·5 m.m.).

The *mycelium* is confined to the paled areas of the needle, and does not enter within the endothelial sheath. The hyphae ramify extensively among the parenchymatous cells between the endothelial sheath and the hypodermal cells. They do not appear to do any injury to these parenchymatous cells. There are no haustoria.

The *peridium* is very resistant, and when emptied of the orange red aecidiospores is white. It ruptures along the summit or ridge when ripe to allow the exceedingly numerous aecidiospores to fall out. It consists mainly of two layers of cells (in some parts of three) very firmly adherent to one another, by the interlocking of the prominent spines which cover them externally. The walls of these peridial cells are 4μ thick, and the cells themselves measure when moistened from 28×20 to $44 \times 29\mu$, or on an average $38 \times 41\mu$.

The *aecidiospores* are formed in very long rows, those towards the basidia being separated from one another by clearly defined intercalary lamellae. They are oval orange red bodies, with thick epispores, beset with numerous and prominent spines, which doubtless aid in their aerial distribution. The dry spores measure on an average $24{\cdot}3 \times 17{\cdot}9\mu$, and when moistened $25{\cdot}4 \times 17{\cdot}9\mu$. After lying 24 hours in water they measured $26{\cdot}4 \times 19{\cdot}6\mu$ on an average. I never succeeded in getting these spores to germinate in cultivations, although I have tried various fluids.

Spermogonia. These are of the usual structure; but are very large and deeply set.

Remarks.—This species must, I think, be considered different from *Aec. Pini* (Willd) Pers., as the aecidia are very different in shape and size. Whilst the species I have described has large *flat* peridia, from 5 m.m. to 1 c.m. in length and 2·5 to 3·5 m.m. in height, those of *A. Pini* are conical or cylindrical and 2 to 2·5 m.m. in height. Moreover, whilst the aecidiospores of the latter are 30 to 34×20 to 22μ those of the Simla species are $26 - 24 \times 19 - 17\mu$.

2. Aecidium brevius, nov. sp.

On *Pinus excelsa*, Wall.

This is an almost equally abundant *Aecidium*, though less prominent than the above, the peridia being much smaller. It is, I believe, a distinct species. I have only met with it on the needles and never on the stem. It is markedly later in appearing to observation than the former. The aecidia begin to appear early in April, and increase in numbers to June. The needles of this host are not altogether annual, though a great many are shed annually, and those attacked by the parasite are apparently always so shed, as after July no vestige of the aecidia remains. New needles begin to emerge from their scaly coverings towards the end of April, and are full grown in July to August. These new needles are never found attacked.

The *aecidia* are like those of the above species, elongated, flattened, orange red bodies, but much smaller (fig. 2, Pl. III). One of ordinary

size measures $\frac{1}{15}$th. inch in length and $\frac{1}{20}$th. to $\frac{1}{30}$th inch in depth. The number of these borne on one needle is usually about four; but varies from one to six, and in exceptional instances even more may be found.

The *mycelium* is confined to the paled portions of the needles and is therefore strictly localised as in the above species. The hyphae ramify among the parenchyma cells between the hypoderma and the endothelial sheath, and does not penetrate within the latter. There are no haustoria.

The *peridium* is very tough and white, consisting of two layers of cells firmly adherent to one another, as in the case of the above species; but the peridial cells are much larger, measuring about 40 × 22μ or 42 × 21μ (figs. 6, 7, Pl. III). This difference is so great as to justify me, I think, in regarding it as a distinct species.

The *aecidiospores* are oval and orange red, with a stout epispore beset with prominent spines. The epispore is often thickened more on one side than on the other (fig. 2, Pl. III). They are formed in long serial rows, and in great numbers within each peridium. Between the lower ones intercalary lamellae are present. The dry spores measure on an average 27·5 × 16·9μ and when moistened, 27·3 × 19·3μ. After lying 24 hours in water they measure 30·2 × 21·2μ on an average. I have failed to observe the germination of these spores also in cultivations, although I have tried them in various media.

Spermogonia. These are of the usual structure; but are very large and deeply set.

Remarks.—I think the differences between these two *Aecidia* are sufficient to warrant their separation as two distinct species. With a view to ascertaining the exact difference in the size of the aecidospores and the peridial cells of the two species I simultaneously treated both in the same way, and then carefully measured them. The needles bearing aecidia were first placed in a mixture of equal parts of glycerine and alcohol and then examined in pure glycerine. The aecidiospores from *P. longifolia* measured on an average of several individual measurements 22·3 × 15μ, whilst those from *P. excelsa* measured 28·6 × 18·4μ. The differences between the aecidiospores and the peridial cells are shown in the following table:

Host.	Aecidiospores.				Peridial cells.	
	Moistened in water.	Dry.	24 hours in water.	Alcohol and glycerine.	Alcohol and glycerine.	Water.
P. excelsa ...	27·3 × 19·3	27·5 × 16·9	30·2 × 21·2	28·6 × 18·4	40 × 22	129·5 × 91·5
P. longifolia	25·4 × 17·9	24·3 × 17·9	26·4 × 19·6	22·3 × 15·0	27·6 × 17·2	38·0 × 41·3

Cooke, considered both species identical (see *Indian Forester*, Vol. III, 1877-78) and named it *Peridermium orientale*, C. but as I think there is no doubt whatever they are quite distinct I have re-named both species.

In a paper describing a *Chrysomyxa* (*C. Himalense*) which is exceedingly common in Simla on *Rhododendron arboreum*, Sm., I have drawn attention to a possible connection between the *Aecidium* on *P. excelsa* and this *Chrysomyxa*,* and have given reasons why a connection with the *Aecidium* on *P. longifolia* is not probable. The occurrence of a double crop of aecidia on *P. longifolia*, of which I did not know when I wrote the paper referred to above, renders it, however, still more difficult to conjecture the life history of this parasite.

N. B.—In order to complete this list I would here draw attention to three other *Aecidia* on other species of the *Coniferae*, namely, two distinct species on the needles of *Picea Morinda* and one on the Deodar. These I had already fully described in this Journal before I commenced a systematic review of all the *Uredineae* of this region. For one of those on *Picea Morinda* (*Abies Smithiana*) described in Vol. LV, Pt. II, No. 1, 1886, I propose to retain the name

3. Aecidium Thomsoni, Berkeley.

although there is some doubt as to the identity of that species with the species in this region; and for the other, described in the same volume, Pt. 2, No. 2, I propose the name

4. Aecidium Piceae, nov. sp.

The species I have described on the Deodar, Volume LV, Pt. II, No. 2, 1886, I now propose naming

5. Aec. Cedri, nov. sp.

6. Aecidium Plectranthi, nov. sp.

On *Plectranthus Coetsa*, Ham.

An inconspicuous and rare *Aecidium* was found first on the 4th July, and then shortly afterwards on a very few bushes in the same locality. The aecidial patches are small, and a single leaf sometimes contained several of them; but usually only one or two. On the upper surface of patches spermogonia could be seen with a field lens, while the under surface bore the peridia. These are short cups open stellately,

* Scientific Memoirs by Medical Officers of the Army of India, Part V, 1889.

and discover brilliant orange red spores. The aecidio-spores are round or oval, beset densely with shallow tubercles or warts, and measure when fresh 25μ in diameter to 26 $\times$ 24μ.

7. Aecidium infrequens, nov. sp.

On *Geranium* (*nipalensis*, Sweet ?)

This is also a very rare *Aecidium*. I have only once found it in July, 1886. The aecidial patches in the only specimen I ever saw were very numerous on the leaves, each division of the five lobed leaf bearing from one to six patches. The patches were about $\frac{8}{30}$ inch in diameter. The peridia were entirely hypophyllous, and burst stellately, showing orange red aecidiospores within. The under surfaces of the leaf patches were yellow, and the upper surfaces greenish yellow. After the aecidiospores have fallen out of the peridia the latter become deep brown, and then look like teleutospore beds.

The aecidiospores are round, or angular when dry, of a pale yellowish colour, and with very thin walls. The spores become detached in rows of three or more. The fresh spores varied in size from 14μ in diameter to 18 $\times$ 16μ.

The peridial cells are thickened on one side: when seen flat they are angular in contour, and measure about 20μ in diameter.

a. HEMIPUCCINIA.

1. Puccinia Iridis, (D. C.)

On *Iris florentina*, L.

Or *Iris pallida*, Lam.

This host is very frequently attacked by a uredo bearing fungus, and I have found it abundantly both in spring (March) and in autumn (September, November). The pustules, which are borne on both surfaces of the leaves equally, are linear and brown, flanked by the rent edges of the epidermis. The spores are round or oval, deep brown, deciduous, falling off without any portion of stalk adhering, and measuring when fresh from 26μ in diameter to 30 $\times$ 24 or 34 $\times$ 20μ. The epispore is spiny or tuberculated. They germinate freely in water after the manner of uredospores. The end of the long germ tube sometimes swells into a head, not, however, separated by a septum (fig. 7, Pl. IV). The spores, whether collected in spring or late autumn from dried leaves, always germinated in the same way. Each spore has three germ pores.

I found the *teleutospores* for the first time at the end of 1889, although I had looked carefully for them in previous years, and then in one locality only. They are therefore rare notwithstanding the

abundant distribution of the uredo form. The dried leaves are covered with black pustules, round to oval, on both sides of the leaf, mostly remaining covered with epidermis, and with the spores firmly adherent. The pustules contained a few uredospores also. The teleutospores are small, much constricted at the septum usually, though the spores vary much in shape, and much thickened at the apex. The fresh spores measured 36 to 44μ in total length, by 14 to 18 in greatest breadth, or 10 to 13 at the septum. The thickening at the apex is 6 to 9μ. The spores did not germinate on being put into water, and I therefore conclude that they require a winter rest.

2. Puccinia argentata, Schulz. ?

On *Impatiens amphorata*, Edgw.

In the middle of September I found this host attacked with a brown uredo bearing fungus; but only in certain localities, and I would characterise it as rare. The upper surfaces of attacked leaves display circular paled patches, and the lower surfaces of these patches bear minute circular brown pustules. Later when the leaf is beginning to wither the invaded areas are conspicuous by their green colour against the yellowed general leaf surface, showing again a lichenoid symbiosis between the chlorophyll cells of the leaf blade and the mycelium of the fungus. A single leaf usually bore immense numbers of these, while the petioles also bore some. Towards the end of September, when the host is beginning to disappear for the season, *Puccinia* pustules are developed, though uredo pustules are still more numerous; but gradually the uredo pustules recede.

The *uredospores* are brown oval bodies, spiny on the surface, and often displaying a nucleus or nucleolar space, and thus resembling a *Uromyces* spore (fig. 11, Pl. I). They are very deciduous, falling off without any portion of stalk adhering, though the place of union with the stalk is usually clearly definable. The fresh spores measured 24 × 16μ on an average. These spores germinated readily in water, throwing out a long simple germ tube, the end being often curiously twisted into an intricate loose knot. Some smaller germ tubes produced a swelling at the end, but this was not separated off by any septum.

The *teleutospores* are plump rounded spores, irregular in size and shape, and with little or no constriction at the septum. Most of them display a small conical colourless thickening at the free end; but some are without this (fig. 11, Pl. I). The spores are readily detached from their beds, and little or no portion of the stalk adheres. They are deep brown in colour, and the external surface is very faintly tuberculated over both cells. An averaged sized spore measured when fresh 32μ in

total length, and 18μ at the septum, which divides the spore into equal parts: a nucleus is contained in each cell. The spores do not germinate immediately after ripening.

3. Puccinia nitida, nov. sp.

On *Polygonum amplexicaule*, Don.

I have never found this fungus actually in Simla; but it is fairly common at Mashobra, a suburb about 6 miles from the station. In one locality many plants were abundantly attacked. Leaves usually bore innumerable pustules, some brown and some black, mostly hypophyllous, rarely epiphyllous. The former are uredo and the latter teleutospore pustules.

The *uredospores* are round to oval, light brown, spiny, and 22 × 24μ in diameter when fresh (fig. 10, Pl. I).

The *teleutospores* are plump, rounded, deep brown, and very slightly constricted at the septum. Each cell has a well marked nucleolar space, and the free end is not thickened (fig. 10, Pl. I). The germ pore of the upper cell is clearly visible a little to one side of the summit. The spores are readily detached, with usually no portion of stalk adhering. The epispore over both cells is finely tuberculated. The spores are very variable in size and shape: some of the smaller squatter spores measure 26μ in total length, by 16μ at the septum, and 19μ in greatest breadth. Larger spores measured 38 to 44μ in length, by 18μ at the septum. The spores do not germinate immediately after ripening.

Remarks.—Saccardo notes three species of *Puccinia* on species of *Polygonum*, namely, *P. Polygoni*, Pers, *P. Bistortae*, Strauss, and *P. mammillata*, Schröter. I do not think the Simla species is identical with any of them. At any rate it is not *P. Polygoni*, *Alb et Schwein*, because the uredo sori in Simla are not irregular and not circinate; the teleutospores are not adherent, no portion of stalk remaining on the detached spores; they do not contract towards the stalk; and are not thickened at the apex.

4. Puccinia Fagopyri, nov. sp.

On *Fagopyrum esculentum*, Moench.

At the beginning of October I found some stray plants of this host growing on a weedy bank far from cultivated fields, largely attacked with a fungus bearing black and dark brown teleutospore and uredo pustules, all hypophyllous, with circular paled areas on the upper leaf surface.

The *uredospores* are pale brown echinulate bodies, oval and measuring 23 × 18μ on an average. The spores germinated in water in the usual way (fig. 9, Pl. I). I have occasionally seen a globular expansion at the end of the germ tube, as shown in the figure; but this is never separated off by a septum.

The *teleutospores* are very deciduous, falling off with only a fragment of stalk adhering. They are dark brown and very variable in size and shape, somewhat constricted at the septum, with a smooth surface, and slightly thickened at the apex. A clear nucleolar space is seen in each cell (fig. 9, Pl. I). The fresh spores measured from 25 to 36μ in total length, by 11 to 13μ at the septum. The septum divides the spore into two almost equal halves. The upper cell is often much broader than the lower, and is more or less globular. The apical thickening is about 4μ in depth, the cell wall elsewhere being about 2μ in thickness. The spores do not germinate immediately after ripening.

5. Puccinia Gentianae, (Strauss).

On *Gentiana Kurroo*, Royle.

I found two plants of this host at the end of December largely attacked with a *Puccinia*, on a hill some miles from Simla to the south (near Solon); but have never seen it again. The plants I found were withered. The under surfaces of the leaves bore numerous black circular isolated pustules. On examining the spores from these they were found to consist of teleutospores with a few uredospores. The spores are readily detached from their beds, coming off with a fragment of stalk usually adhering.

The *uredospores* are oval, pale brown bodies, spiny, measuring 26 × 22μ after lying 24 hours in water.

The *teleutospores* are plump and rounded at both ends, and slightly if at all constricted at the septum. The epispore is very finely tuberculated over both cells, and is uniformly thick, with the exception of a very shallow mamillated thickening at the free end. Each cell of the spore exhibits a clear nucleolar space or body. After lying 24 hours in water these spores measured from 38 to 40μ in length by 25 to 26 in breadth. They are very uniform in size. They do not germinate immediately after ripening. Occasionally a single celled teleutospore may be seen.

Remarks.—This is most probably *P. Gentianae* (Strauss) as the characters of both uredo and teleutospore agree; but I have not seen any *Aecidium*. The locality, however, in which I found the fungus is not familiar to me: I have only once visited it in winter.

b. MICROPUCCINIA, Schröter.

6. Puccinia Leptodermis, nov. sp.

On *Leptodermis lanceolata*, Wall.

For description see above under *Melampsora Leptodermis*.

7. Puccinia Wattiana, nov. sp.

On *Clematis puberula*, H. f. and T.

This fungus was collected by Dr. George Watt in the Sutlej valley, near Suni, 2,500 ft., in October 1889. The leaves were covered with blackened, more or less circular patches, on the under surfaces of which were numerous dark brown pustules, with a marked circinate arrangement: a few pustules, however, were found also on the upper leaf surface. The blackened areas of discoloration measured 3—4 m.m. in diameter, and each leaf bore numerous such patches, from 5 to 30. Some pustules were also discovered on the petioles and ultimate stems.

The spores are readily detached, coming off with a considerable portion of stalk adhering. They are deep chestnut brown, smooth on the surface, rounded at both ends, with little constriction at the septum, and often presented a small colourless mammilla at the free end, which is not otherwise thickened. Spores were often seen divided into 3 and even 4 cells, and a few were single celled. There were no uredospores. The spores measured, when just moistened 42 — 37 × 21 — 20 μ.

The spores, which had been preserved *in situ* in ordinary botanical drying paper, were placed in water on the 4th May 1890, and on the following day they were found to have germinated freely. The promycelia are usually quite short, though sometimes long, and are colourless. It is remarkable that whilst the upper promycelium issues from the apex as usual, the lower one is emitted from a point close to the stalk. The sporidia are oval and colourless, measuring 15 — 14 × 8 — 7μ, and are borne on short sterigmata. No secondary sporidia were formed.

Remarks.—Saccardo mentions 2 species of *Puccinia* on species of *Clematis*, *viz.*, *P. stromatica*, Berk. et Curtis, and *P. insidiosa*, Berk. In the absence of measurements it is impossible to determine whether the species I have described is identical with either. The general characters of the spores of *P. insidiosa* are unlike those I have described. The spores of *P. stromatica* are somewhat similar; but the sori are said to be diffuse and ruddy. I am inclined to think that the species I have described is distinct, and I have named it after Dr. G. Watt. I regret being unable to give figures of the spores, as I obtained the specimens after this paper had been sent to press.

N. B.—Since the publication of Part II of this List I have been able to follow the complete life history of the *Puccinia* there described under the name *P. helvetica*, Schröter, and there is no doubt that it is a new species. Aecidial fructification is entirely suppressed. I have given a full description of it under the name *Puccinia Collettiana* in the Scientific Memoirs by Medical Officers of the Army of India, Part V, 1889.

DESCRIPTION OF THE PLATES.

Plate III.

Fig. 1. *Uromyces Vossiae*, uredospore. 2, ditto, teleutospore. 3. *Phragmidium subcorticium*, teleutospore, × 220. 3. a, ditto, aecidiospore. 4 *Phragmidium Rubi*, teleutospore. 5. ditto, germinating, with sporidial formation. 6. ditto, uredospores. 7 *Melampsora Salicis Capreae*, transverse section through teleutospore bed, × 220. 8. ditto, through uredo bed, × 220. 9. *Puccinia Fagopyri*, teleutospore, and germinating uredospore. 10. *Puccinia nitida*, three teleutospores and uredospore. 11. *Puccinia argentata*, two teleutospores and uredospore.

Plate IV.

Fig. 1. *Melampsora Sancti-Johannis*, transverse section through teleutospore bed, × 150. 2. ditto, transverse section though leaf bearing uredo bed and spermogonia, × 220. 3. ditto, natural appearance of wholly involved very young shoot. 4, ditto, surface view of teleutospore bed. 5. *Melampsora Leptodermis*, transverse section though young teleutospore bed, × 220. 6. ditto, though uredo bed, × 220. 7. *Puccinia Leptodermis*.

Plate V.

Fig. 1. *Aecidium complanatum*, natural appearance. 2. *Aec. brevius*, natural appearance. 3. *A. complanatum*, transverse section though peridium. 4. ditto, peridial cells seen flat. 5. ditto, lowermost cells of row of aecidiospores, showing intercalary lamellae. 6. *A. brevius*, peridial cells seen flat. 7. ditto, transverse section though peridium. 8. *A. complanatum*, aecidiospores. 9. *Aec. brevius*, aecidiospores.

Plate VI.

Fig. 1. *Chrysomyxa Piceae*, transverse section though fruit body, × 150. 2. *Coleosporium Campanulae*, transverse section though teleutospore bed, × 220. 3. *Coleosporium Clematidis*, transverse section through teleutospore bed on leaf of *C. montana*, × 220. 4. *Coleoporium Plectranthi*, transverse section through teleutospore bed, × 220. 5. *Col. Clematidis*, promycelium with sporidial formation (*C. montana*). 6. *Caeoma Mori*, sterile and fertile aecidospores. 7. *Puccinia Iridis*, germinating uredospore. 8. *Uredo Gomphrenatis*, uredospore. 9. *Uredo cronartiiformis*, uredospore. 10. *Coleosporium Campanulae*, uredospore.

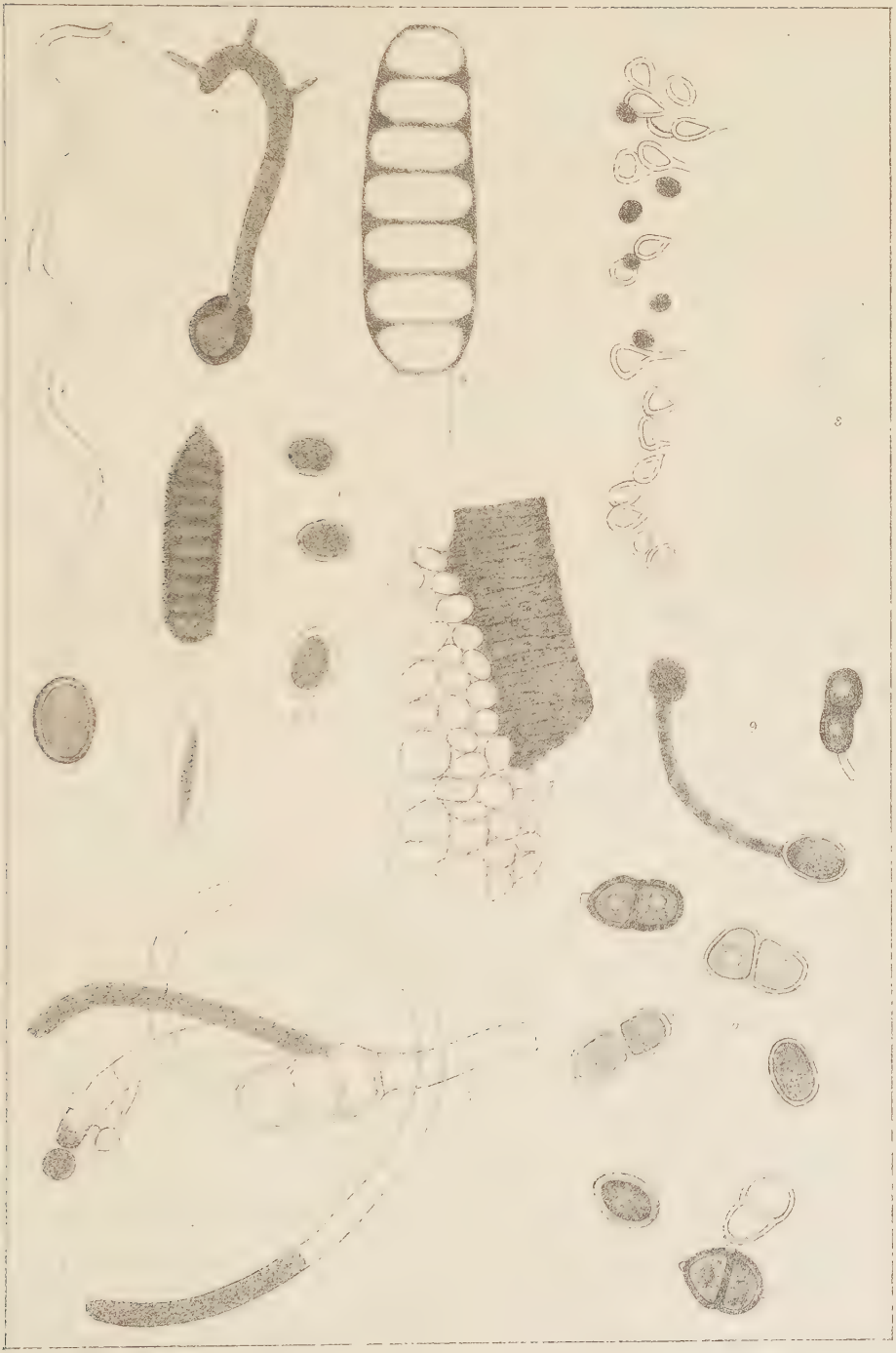
N. B.—Unless otherwise specified all figures are × 350.

INDEX.

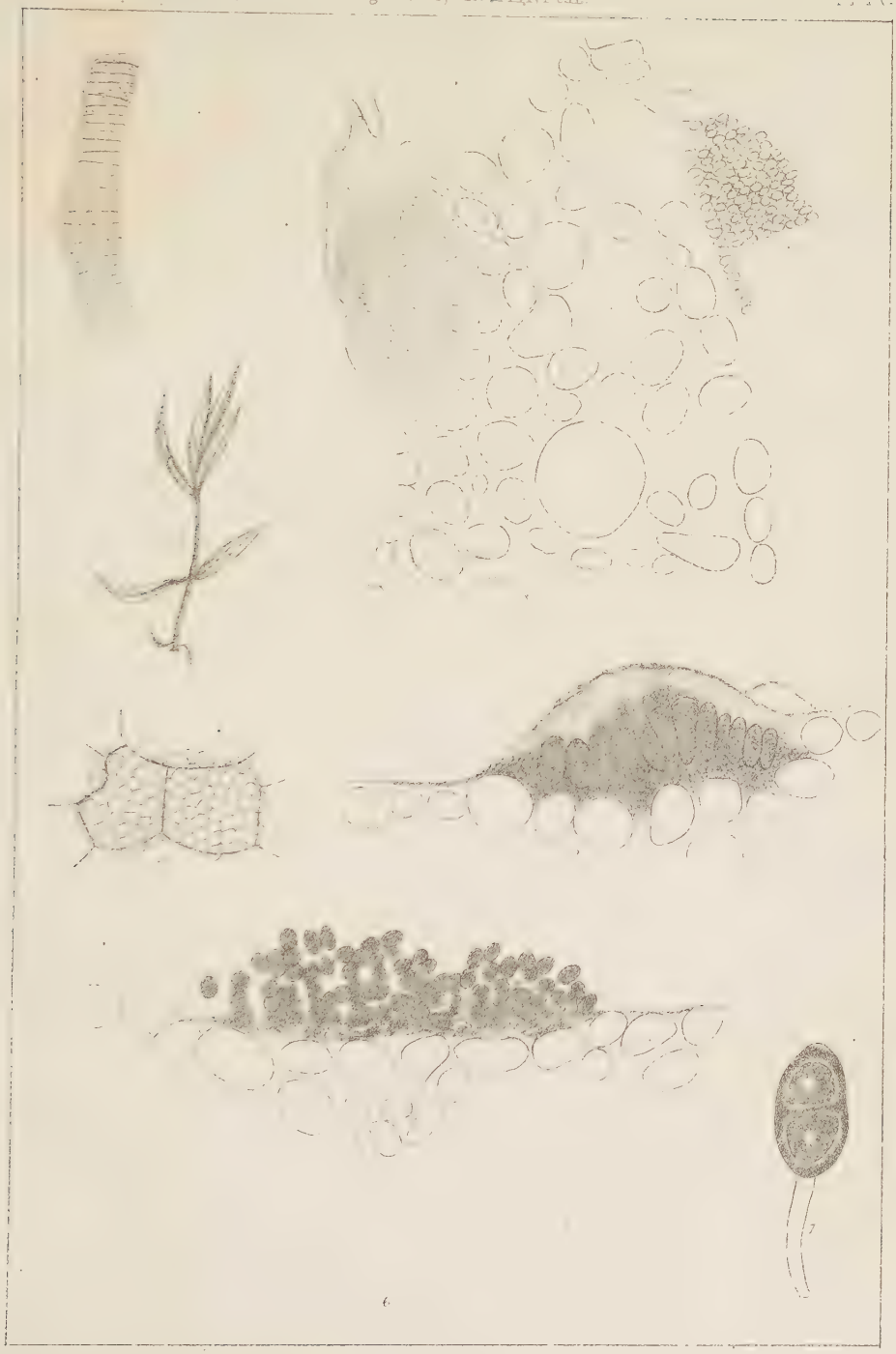
I = Vol. LVI, Pt. II, No. 3, 1887.
II = ,, LVIII, Pt. II, No. 2, 1889.
III = ,, LIX, Pt. II, No. 2, 1890.

Aecidium brevius, III, p. 102.
,, Cedri, n. s., III, 104.
,, Complanatum, n. s., III, 100.
,, Compositarum Martius, I, 373.
,, infrequens, n. s., III, 105.
,, Jasmini, n. s., I, 363.
,, leucospermum, D. C., I, 361.
,, Piceae, n. s., III, 104.
,, Plectranthi, n. s., III, 104.
,, Saniculae, n. s., I, 352.
,, Strobilanthis, n. s., I, 369.
,, Thalictri flavi, D. C., I, 362.
,, Thomsoni, Berk, III, 104.
,, Urticae, Schm. v. Him., I, 368.
Caeoma Mori, n. s., III, 97.
,, Smilacis, n. s., III, 95.
Chrysomyxa Himalense, n. s., III, 93.
,, Piceae, n. s., III, 94.
Coleosporium Campanulae, Pers., III, 90.
,, Clematidis, n. s., III, 89.
,, Plectranthi, n. s., III, 89.
Gymnosporangium Clavariaeforme, Jacq., I, 370.
,, Cunninghamianum, n. s., III, 92.
Melampsora Leptodermis, n. s., III, 86.
,, Sancti-Johannis, n. s., III, 84.
,, Salicis Capreae, Pers., III, 88.
Monosporidium Andrachnis, n. s., I, 371.
,, Euphorbiae, n. s., I, 364.
Phragmidium incompletum, n. s., III, 83.
,, quinqueloculare, n. s., III. 82.
,, Rubi, Pers., III, 81.
,, subcorticium, Schrank, III, 79.
Puccinia Acetosae, Schum., II, 240.
,, Andropogi, Schw., II, 246.
,, Anthistiriae, n. s., II, 246.
,, argentata, n. s., III, 106.
,, Arundinellae, n. s., II, 245.
,, Caricis, Schm., II, 244.
,, Caricis filicinae, n. s., II, 250.
,, Chrysopogi, n. s., II, 247.
,, Circaeae, Pers., II, 235.
,, Collettiana, n. s., III, 110.

Puccinia coronata Corda, II, 248.
,, Fagopyri, n. s., III, 107.
,, flosculosorum, Alb. et Schw., II, 238.
,, Fragariae, n. s., I, 359, II, 244.
,, Galii, Pers., II, 239.
,, Gentianae, Strauss, III, 108.
,, Geranii silvatici, Karst., II, 236.
,, Graminis, Pers., I, 367, II, 249.
,, helvetica, Schrt. (see P. Collettiana).
,, Iridis, D. C., III, 105.
,, Leptodermis, n. s., III, 109.
,, Menthae, Pers., II, 242.
,, nitida, n. s., III, 107.
,, Pimpinellae, Strauss, I, 356, II, 244.
,, Polliniae, n. s., I, 369, II, 243.
,, Rosae, n. s., II, 233.
,, Roscoeae, n. s., II, 237.
,, Saxifragae ciliatae, n. s., II, 234.
,, Urticae, n. s., II, 234.
,, Violae, Schum., I, 354, II, 244.
,, Wattiana, n. s., III, 109.
Uredo Apludae, n. s., III, 99.
,, Bupleuri, n. s., III, 98.
,, Cronartiiformis, n. s., III, 98.
,, Deutziæ, n. s , III, 100.
,, Eupatoriae, D. C., III, 98.
,, Gomphrenatis, n. s., III, 99.
Uromyces Cunninghamianus, n. s., III, 76.
,, McIntirianus, n. s., III, 79.
,, Solidaginis, Niessl., III, 77.
,, Strobilanthis, n. s., III, 78.
,, Valerianae, Schum., I, 352, III, 77.
,, Vossiae, n. s., III, 76.



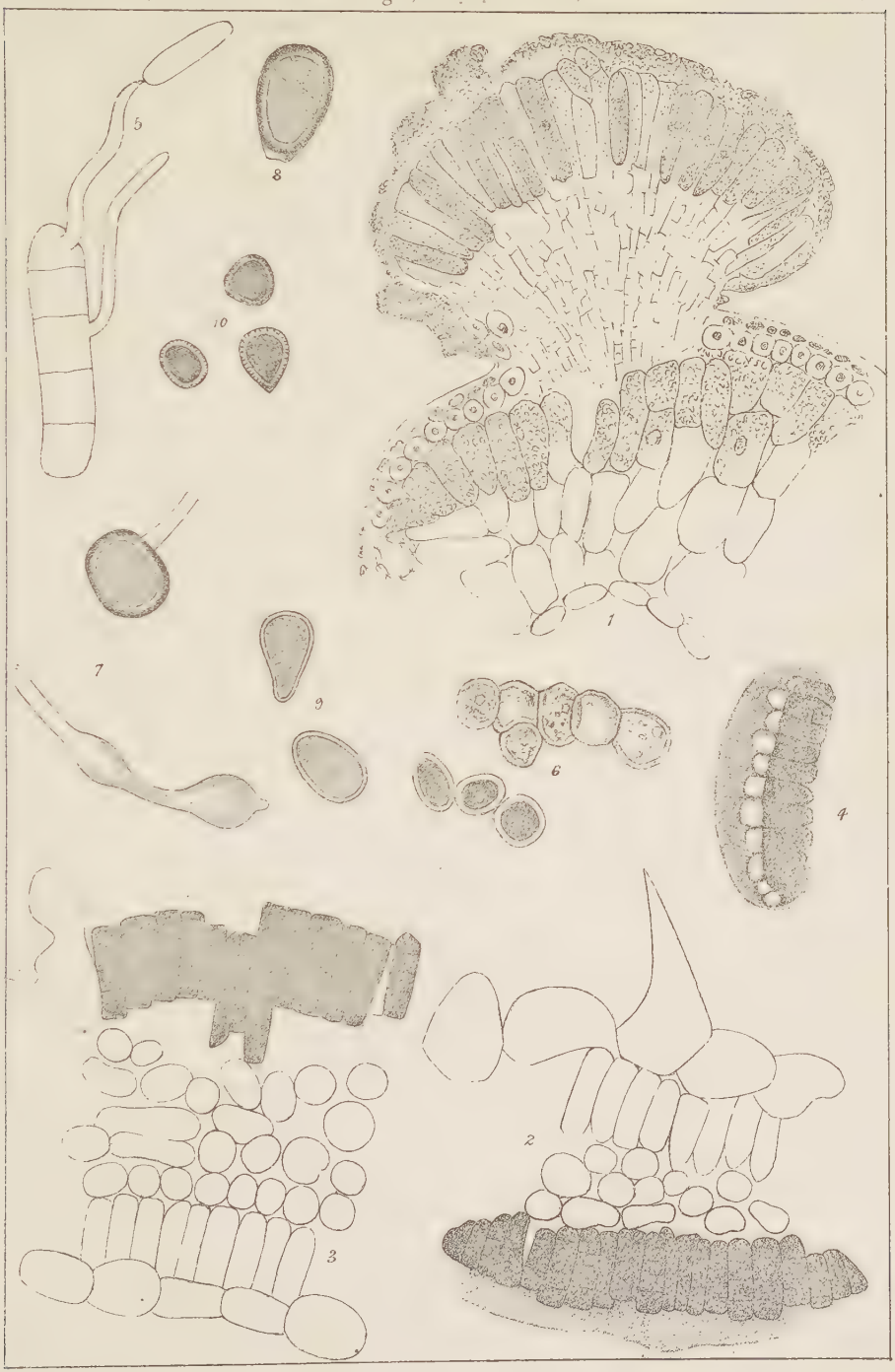
A. Barclay, del. Lith. K. D. Chandra.



A. Barclay, del.

Lith. by K.D. Chandra

A: Barclay, del. Lith: by A. C. Singha.



A. Barclay, del.

Lith. by A. C. Singha.